sunwall design competition

UNITED STATES DEPARTMENT OF ENERGY • NATIONAL SOLAR DESIGN COMPETITION

SUNWALL AWARD CEREMONY
WASHINGTON, D.C. – OCTOBER 13, 2000
U.S. ENERGY SECRETARY, BILL RICHARDSON

"For anyone who's counting, the sun will appear to move across our sky 7,305 times in the next 20 years. During that period, worldwide energy consumption will increase by nearly 80 percent. It's a staggering amount so we need to turn increasingly to clean alternative sources of energy – like the sun – to fuel our needs.

Today, we take a step that I hope shows just how serious we are about redoubling our efforts to capture some of the sun's vast energy and making it work for us in ways that have been underutilized and overlooked.

We are here to unveil the winning design in the United States Department of Energy's Sun Wall National Design Competition. It is a spectacular solar design that we hope will cover this entire south wall of the Forrestal Building. As you see, the wall today is a blank, unappealing concrete mass with little value beyond keeping the elements out and our people and equipment in.

There are walls just like it throughout the country, indeed, throughout the world; far too many to count. They are useful, but as the term is applied to walls like this one, it is time to see if we can expand the meaning of utility.

It all grows from a challenge issued a little more than two years ago. In July 1998, Assistant Secretary Dan Reicher and I were here to dedicate the 3-kilowatt solar electric array on the railing of this wall. Tapping into the sun's energy is not a new idea, and what we did here in 1998 showed that we were probing for possibilities.

Dennis Hayes, founder of Earth Day, was with us at the time. He commended us for the initiative, but he also challenged us to do more. We agreed that the next step was to cover this entire wall with a human-designed solar system.

So we created a national competition to get the best architectural firms and architectural students in the country to develop a conceptual design. The competition had two goals: First, the architectural community could learn the benefits of integrating solar technology into buildings. And, second, we hoped to get a stunning design to help us seek approval for the Forrestal project. Both objectives have been obtained.

Solar energy systems integrated into or onto buildings is the fastest-growing segment of the solar energy market. The overwhelming response that we got to the Sunwall Design Competition shows the tremendous interest within the United States for solar energy utilization.

There were 501 individuals or teams that registered. Of that total, 115 actually submitted entries. A jury of noted professionals in architecture, solar engineering, and public building design judged entries.

The National Capital Planning Commission and The Commission of Fine Arts still must review and approve the winning design before it can be built onto the Forrestal Building. We're optimistic because part of the challenge of this competition was to create a design that could ultimately win approval.

Aesthetics was the most important consideration. The design had to be aesthetically tasteful and in harmony with the architecture of the Forrestal Building and its surrounding area. We required that a minimum of 100 kilowats be generated by the design. And we required that application of the design be cost effective so that we could justify the public expenditure.

The Energy Department hopes to lead by example through this project. If constructed, the Sunwall not only would be the largest solar system on a Federal Building, it would create an international landmark for the city of Washington, D.C. It would demonstrate the Energy Department's commitment to developing clean energy technologies to power the 21st century. And it would show how the beauty and grandeur of public buildings can be compatible with environmental sensitivity. I want to thank everyone who participated, and I pledge that the Energy Department will do everything it can to ensure that this spectacular design ends up on this unspectacular wall where it belongs."

SUNWALL

NATIONAL SOLAR DESIGN COMPETITON

SPONSORED BY

U.S. DEPARTMENT OF ENERGY

NATIONAL RENEWABLE ENERGY LABORATORY

IN COOPERATION WITH

THE AMERICAN INSTITUTE OF ARCHITECTS

ARCHITECTURAL ENGINEERING INSTITUTE

PUBLISHED 2001

▲ SUNWALL • FORRESTAL BUILDING

AERIAL VIEW OF THE NATIONAL MALL • WASHINGTON DC ▼

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SOLOMON CORDWELL BUENZ & ASSOCIATES
MARTIN WOLF
MARK FRISCH
DEVON PATTERSON
DUANE CARTER

OVE ARUP & PARTNERS
MAHADEN RAMAN
DAVID M. SCOTT

PROJECT NUMBER: 280

JURY COMMENTS

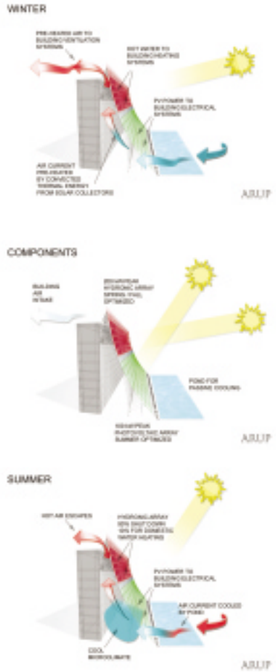
"... the winning scheme has this pond of water. Not only is it interesting visually, it's part of the energy solution...wind will blow over the water and cool the air around the space."

" The designers knew that people would be drawn to the wall, so they reached beyond the two-dimensional to create something visually bold, not just environmentally solid."

"The winner is also very rich in that in addition to the solar electric, photovoltaic cells, there is solar thermal, where water is heated in a solar thermal array, which is very efficient.

There is also a cavity, an airspace between the layers of glass that heat air during the winter months; and there's the passive cooling off of the water pond as well. There are so many things: behind that wall are stacks that create ventilation. So there were multiple issues that were being addressed in a very integrated, sophisticated way, which was a big part of why we chose this one."

"They've provided shade in the summer, with the solid photovoltaic part, then they've got the glass part, which allows sun through in the winter time, so you don't have the cold air behind it."



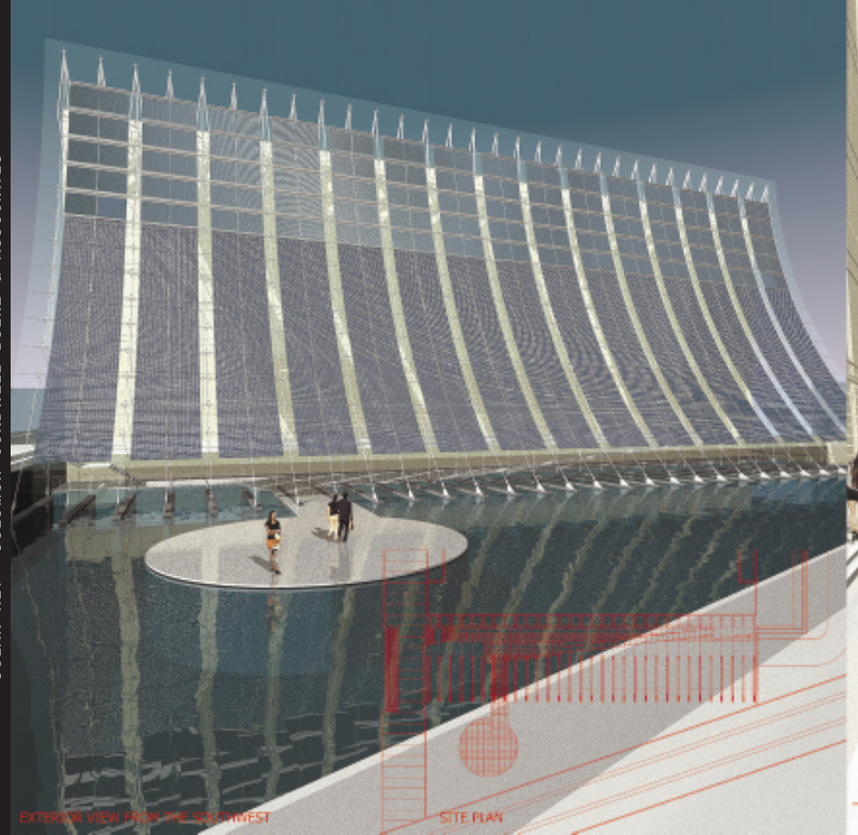
SOLAR NET

In celebrating clean energy technologies, the skin is created with an array of modular solar thermal and photovoltaic collector panels. The collector surfaces are organized in patterns of solids and voids allowing light to transmit through to the interior. Each collector surface has its own texture, giving the composition a visually stimulating appearance. From mid-fall to early spring, when the sun is relatively low in the sky, thermal collectors in the upper part of the wall use incident solar radiation to generate hot water for use in the building heating systems. A peak heat output of 200 kW is predicted in September. In the summer, when the sun is high in the sky and building electrical demands are at their peak, photovoltaic panels in the lower part of the wall generate electricity for use in the building. Calculations suggest a peak generating capacity of 100 kW in June. The overall efficiency of the solar collection array is improved by making use of convected heat from the back of the collector surface. In winter, this convected heat is trapped in a glazed cavity behind the array and is drawn into the building ventilation systems as preheated fresh air. In summertime, the convected heat is allowed to escape at the top of the array and this draws in a current of air at the base of the wall. The incoming air is passively cooled as it passes over a reflecting pool, thereby improving comfort conditions in the occupied space below the wall.

The structure is a series of curved primary cable trusses spanning between the vertical concrete wall and the reconfigured ground plane. Steel brackets, delicately attached to the concrete wall, serve as mastheads for the sweeping cable trusses. This curvature is utilized to gain maximum benefit from seasonal variations in solar altitude. The trusses derive their lateral stability from a second layer of shallow perpendicular trusses. A glazed cavity for transporting convected heat back to the building is formed by buttoning an inside skin of clear glass to the secondary trusses directly behind the photovoltaic panels.

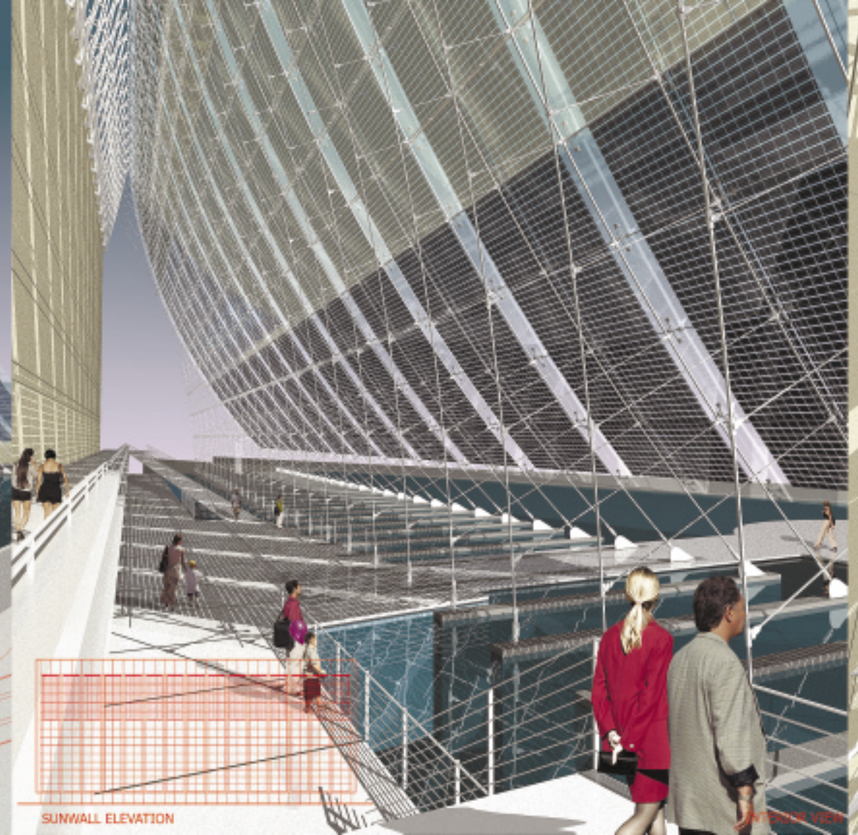
The solution uses a solar skin to create both sweeping exterior planes and soaring interior spaces energizing the south facade of the Forrestal Building. The clean energy produced by the wall is seamlessly channeled back into the building in the form of electricity, hot water, and convected heat. The composition integrates solar technology into a facade system in a thought-provoking fashion, demonstrating that new technologies do not need to be forced to respond blindly to pre-existing conditions nor divorced from rules governing the fundamental principles of contemporary design.

SOLAR NET • SOLOMON CORDWELL BUENZ & ASSOCIATES



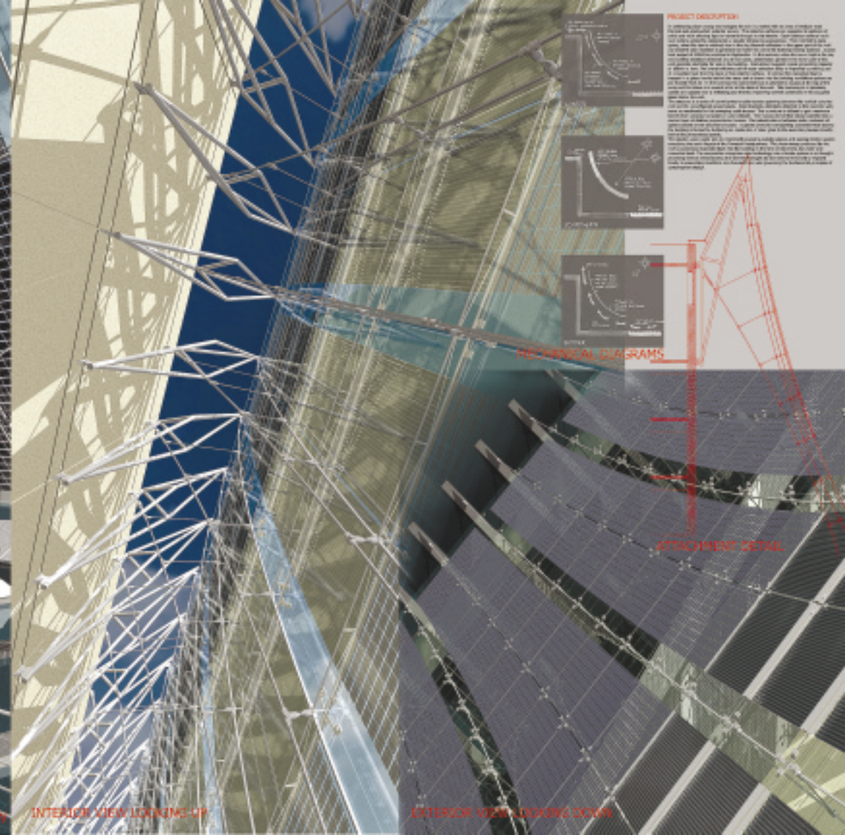
EXTERIOR VIEW FROM THE SOUTHWEST

SITE PLAN



SUNWALL ELEVATION

INTERIOR VIEW



INTERIOR VIEW LOOKING UP

INTERIOR VIEW LOOKING DOWN

PROJECT DESCRIPTION

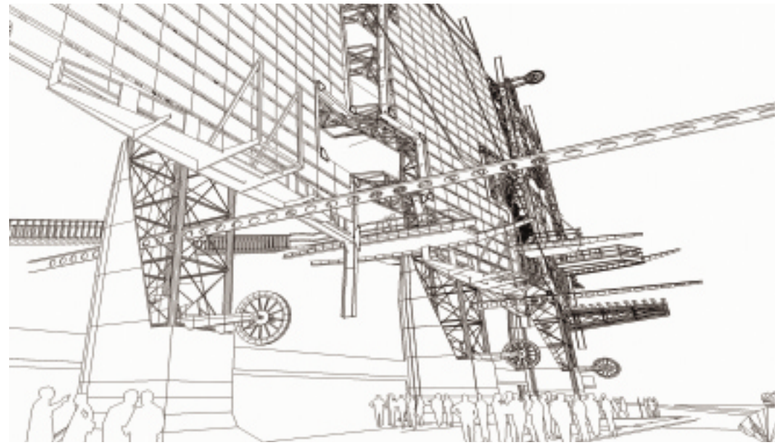
MECHANICAL DIAGRAMS

ATTACHMENT DETAIL

UNIVERSITY OF TEXAS, SAN ANTONIO
MAHESH SENAGALA

TEAM MEMBERS
MADHU DUTTA

PROJECT NUMBER: 267



JURY COMMENTS

"... it made an interesting statement, that solar doesn't have to be 'solar,' it could be very playful, imaginative, fun function on the plaza that generates electricity as well. So it's kind of neat, almost the polar opposite of the first one that was chosen... it's very playful and poetic that way."

"As a concept, it shows a way to treat the solar so it is not just an appliqué stuck on the building. This is more sculptural, playful, not just a big wall of glass. Hopefully people will realize that they too can do something to bring this into their building, and do it in their own way."

SOLAR SAILS: AN INSTALLATION

The ensemble includes four sails, a spinal stair, four needles of time, a tree of life, and a plaza of celebration.

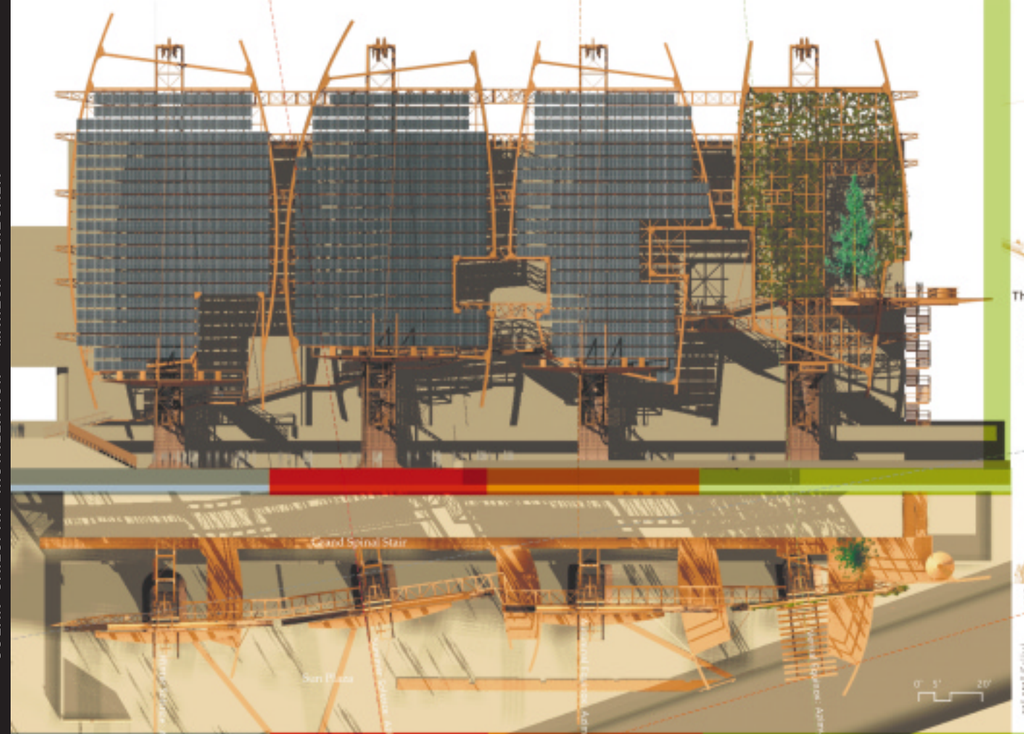
This proposed solar installation addressed the issues at hand on three levels: physical, institutional, and ethereal. Four sails representing four seasons stand firmly rooted in the ground and away from the south wall of the Forrestal Building. The crucial space between the solar sails and the south wall of the Forrestal Building contains a grand stair that ascends toward the east. At the end of the climb would be an evergreen tree framed by the spring sail.

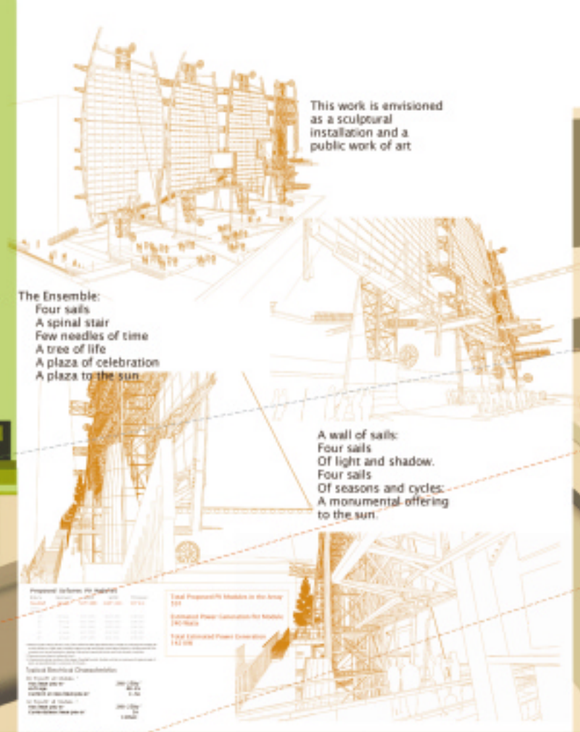
Three sails—Winter, Summer, and Autumn—house BP Solarex(TM) photovoltaic modules, the fourth sail (Spring Sail) is a metallic framework for seasonal vines to grow. Thus, the fourth sail comes to life only in spring. The 591 photovoltaic modules would produce, at their peak, 142 kW of electricity. The sails are moored according to the seasonal solar azimuth. The wall of sails is the seasonal circle cut open to form a jagged line.

The design is more than mere power generation infrastructure. It is an institution of poetic rituals that would connect the mortals to the land, the sky, and the sun. The otherwise blank southern wall and the banal parking lot (where the solar needles would cast the shadows of time) would be transformed into monumental public places through the jagged wall of solar sails. It is a monumental and poetic offering to the sun.

SECOND PLACE

SOLAR SAILS: AN INSTALLATION • MAHESH SENEGALA





Solar Sails: An Installation

ROGER WILLIAMS UNIVERSITY
CHARLES HAGENAH

BEKAERT ECD SOLAR SYSTEMS LLC
TERRANCE PARKER

BP SOLAREX
GARY W. LIENESCH

SOLAR ADVISOR
ALDEN HATHAWAY

PROJECT NUMBER: 285

3

JURY COMMENTS

"The top three winning designs actually create a sliver of space behind it, encouraging you to go in there."

"The top three schemes that were selected all play with light in an interesting way. We thought, there's something about the way photovoltaics are evolving that plays with light and shadow and creates a light-filtering effect that can make these spaces a lot nicer to be in."

"The one here, which is really a hanging curtain, is extremely practical. You could probably actually build it based on the schematic available right now. Depending on how you anchor it down, it could be either more or less flexible; it could be really interesting. Maybe it could move a little bit in the wind. It doesn't have a lot of moving parts, even though it looks like it has lots of stuff happening."

POWER OUTPUT

Roof panels: BP Solarex Panels, MSX-240 (44.5"x74.9"; 208 panel array, 240 W each):	**49.9 kW**
MSX-120 (43.8"x39"; 16 @ 120 W):	**1.9 kW**
SunCurtain panels: UNI-SOLAR Panels, US64 (16"x9'; 756 module array, 64 W each):	**48.4 kW**
(Summer: 168 @ 55º; 588 @ 90º - Winter: 756 @ 55º)	
Total Power:	**100.2 kW**

*Note: The wall is totally shaded during mid summer sun, reducing power requirements for AC loads.

SUNCURTAIN / SUNHALL

This design proposal forms an urban space for people to both enjoy and learn from. It is low cost in materials and assembly, and invites technological changes, maintenance, and replacement in the future.

An open space for people is formed in front of the shimmering SunCurtain, and behind it is an impressive SunHall. A new stair connects the two levels.

The vertical curtain's dark and light geometric surfaces and spaces are a conscious response to the concrete and glass context of the existing building, and they allow it to fit comfortably on the building.

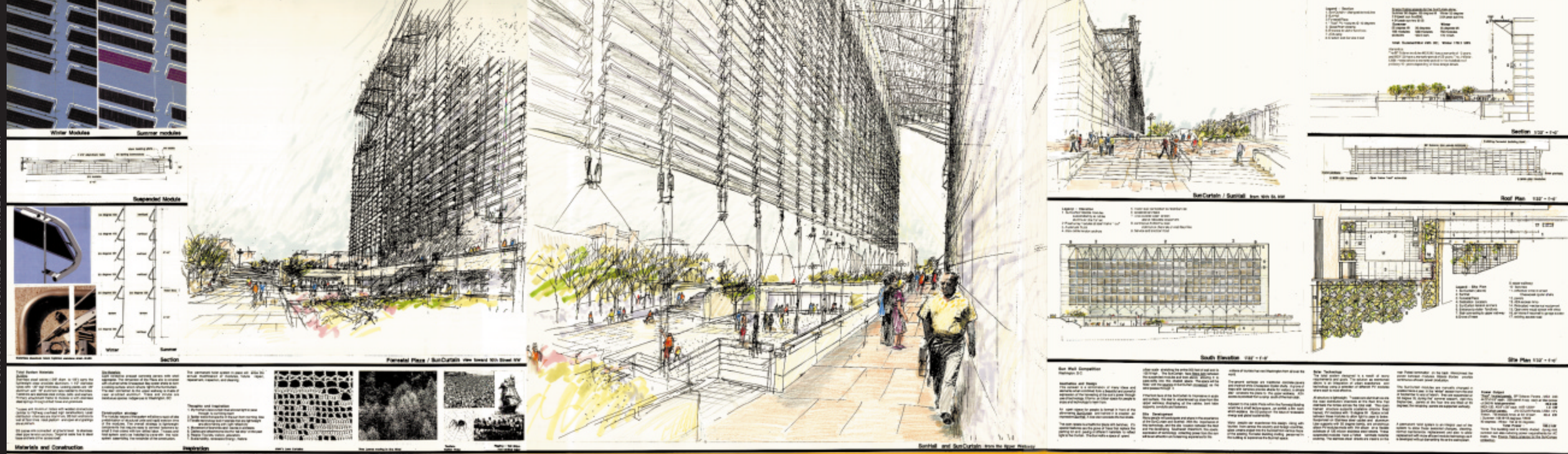
The open space in front of the curtain is a traditional plaza with benches; its special features are the grove of shade trees that replace the parking lot and new paving of crushed Chesapeake Oyster shells to reflect additional light to the Curtain.

The SunHall is a space of grand urban scale stretching the entire 300 feet of wall and reaching 100 feet high. The SunCurtain face filters light between the suspended modules above, allowing it to pass softly into this shaded space. The space will be filled with the sounds of SunCurtain movement as the wind passes through it.

SunCurtain is impressive in scale and surface. The back side of the SunCurtain is experienced from the upper walkway displaying all the stainiess steel cables, PV substrates and fasteners, and the polished aluminum bent tube supports and structure.

Adjacent to the public plaza, within the Forrestal Building, would be a small lecture space, an exhibit, and a film room that explains the U.S. policy on renewable energy and global sustainability.

SUNCURTAIN / SUNHALL • CHARLES HAGENAH



SUNWALL

SUNWALL

SUNWALL

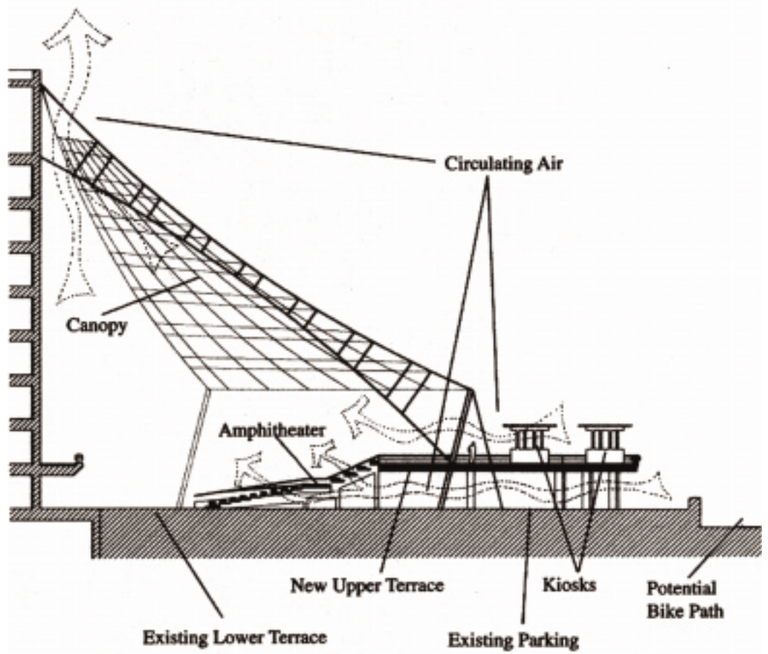
YALE UNIVERSITY
SAM BATCHELOR

ARROWSTREET INC.
JIM BATCHELOR

BUILDING SCIENCE ENGINEERING
MARC KELLEY

UNIVERSITY OF ARIZONA
RICHARD LARRY MEDLIN ARCHITECT

PROJECT NUMBER: 355



SECTION SHOWING AIR CIRCULATION

SHADING SUNWALL

The significance of this site goes back to the earliest plans for the nation's capital. In the 1790s, Pierre Charles L'Enfant's intersecting avenues highlighted the importance of this location. At the turn of the next century, the McMillan Commission Plan instilled new visions for the Mall and this quadrant of the city. Nonetheless, infrastructure and transportation have taken the upper hand in shaping this urban landscape. Once again we find ourselves at the turn of a century, looking to this site and its environs as we consider the future of the city's fabric.

This proposal seeks to utilize solar energy to demonstrate that technology and infrastructure can, in fact, enliven urban spaces. It reactivates the axis between the Jefferson Memorial and the Capitol, as well as breathing new life to the 10th Street Mall. By creating shade, air movement, and cooling in addition to electricity, this plan transforms a wall into a space. It is an opportunity to bring community spirit, tourism, and pride to this historic triangle. This Shading Sunwall reaffirms the historic aspirations of L'Enfant and the McMillan Commission, and projects a contemporary vision of a vibrant and sustainable future for Washington, D.C.

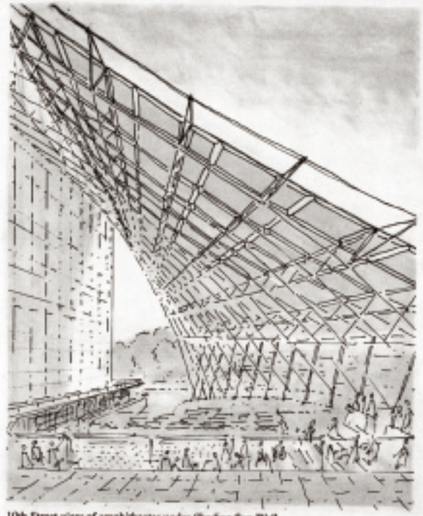
JURY COMMENTS

"The student one, which we didn't know was a student one, was competing in the great draped solution, cable-formed approach. It was very strong—in fact, one of the elements it had was collector panels that were clearly floating. They don't suggest a solid sheet, but are actually individual tiles floating in a grid of wires. That we thought of as positive, it would make it much easier to get the clearances to build it. It also would move more. It didn't have as many energy strategies on the board as the winner did, but it clearly was extremely creative."

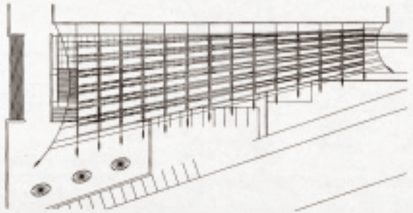
"It's so interesting that the student scheme was right up there at the top with the rest of them."

"It was slightly more roof than wall, in that it angled out more and captured more plaza space. The reason why it didn't make the final cut was just because the other scheme that we chose as the first scheme had more design synergy and more energy strategies integrated into it."

SHADING SUNWALL • SAM BATCHELOR



10th Street view of amphitheater under Shading Sun Wall



Plan View from above

Shading Sunwall

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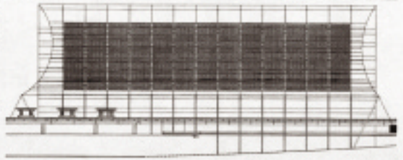
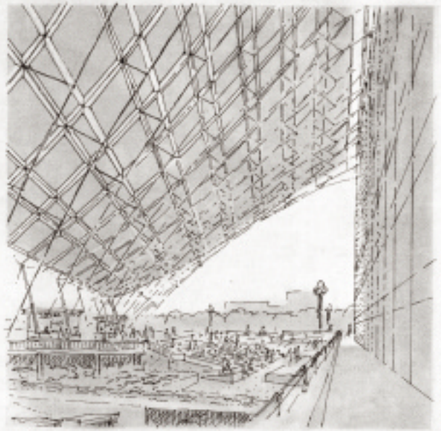
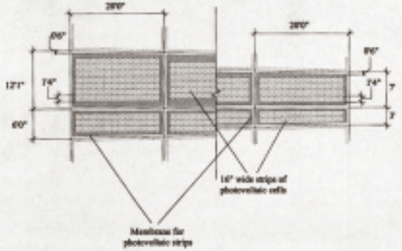


Elevation showing Network Grid and Collectors



Underneath canopy looking towards 10th Street mall

Panels at maximum and minimum condition



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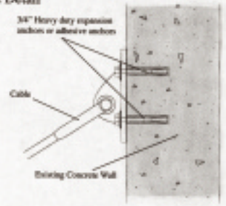
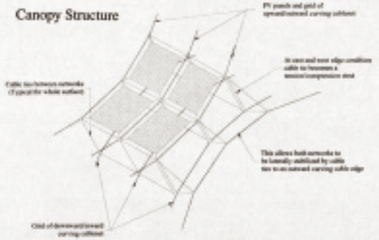


Energy Integration

Canopy Structure



Historic Connections to a Sustainable Future

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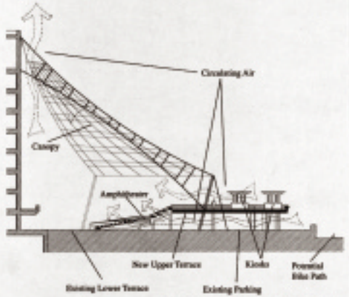
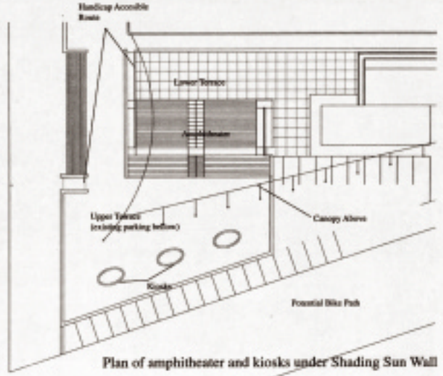
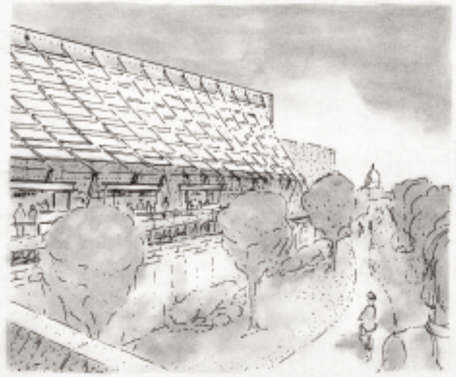


Section showing air circulation



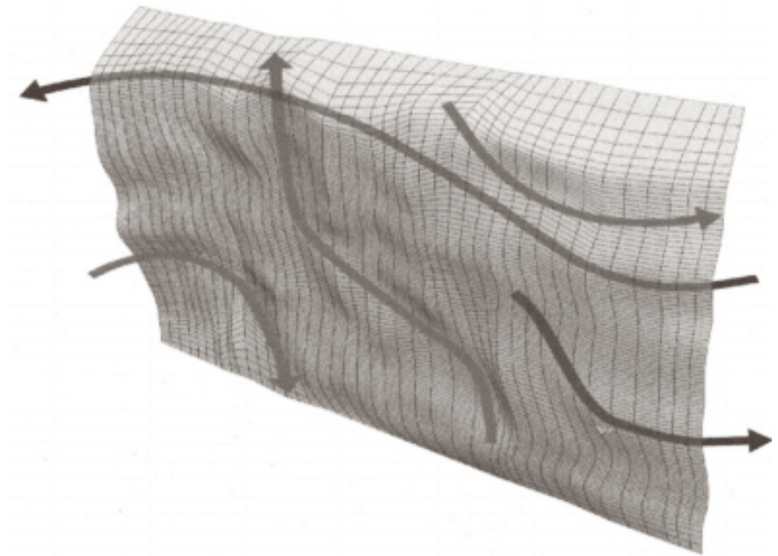
Plan of amphitheater and kiosks under Shading Sun Wall



View to Capitol with potential bike path

ROE + WU
STEVEN ROE

PROJECT NUMBER: 280



THE DYNAMIC NET RESPONDS MORPHOLOGICALLY TO FLOWS -BOTH CLIMATIC AND ELECTRIC- ACROSS IT.

SOLAR GRASS FIELD

The Solar Grass Field is a vertical solar collector that interacts with the persistent flows of weather and climate to maximize the generation of solar power and also to generate a constantly changing visual appearance. It not only produces electricity, but also demonstrates the complex, continuous, and entirely unpredictable interaction of buildings and their environment.

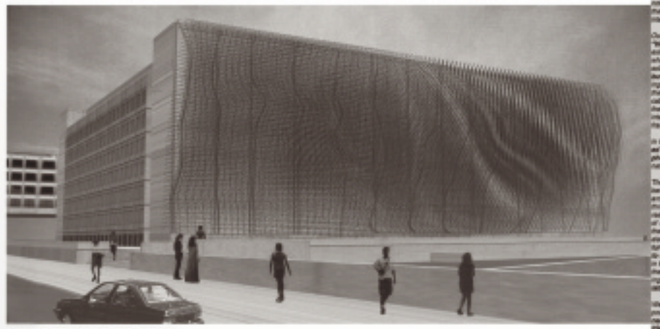
Our design takes the form of hundreds of flexible solar collectors (or *blades*) supported by a *dynamic net* consisting of steel cables. The wind blowing through the structure is allowed to deflect it, while the newly produced solar power flowing through the cables of the net causes them to rotate. Preprogrammed information about the sun's position then allows the exposure of the blades to be maximized. The blades would consist of flexible photovoltaic cells fixed to thin stainless steel strips and covered with a non-rigid transparent surface called Tefzel.

The whole structure would be continuously changing in response to changes in the weather. The solar "grass" blowing in the breeze would be the most obvious of these. The other changes would occur at a slower pace, causing variations over days or longer periods—the installation would never look the same way twice.

JURY COMMENTS

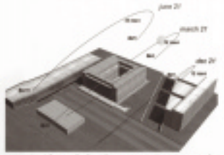
"We felt the Solar Grass Field was not practical, but just intriguing and really creative. It's one of those far-out ideas, and one day people will figure out what to do with this kind of interesting image in the future. We just felt it was so engaging as an image that it deserved recognition."

SOLAR GRASS field

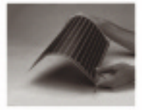


VIEW FROM 10 ST. MALL

grass has a naturally beautiful but unpredictable nature -thousands of individual blades respond independently to changes at an atmospheric level creating largescale patterns of turbulence.



we start by analyzing the movements across and around the wall -including the movement of the sun



flexible amorphous-silicon photovoltaic cells can respond to changing forces in several directions at once

the dynamic net responds morphologically to flows -both climatic and electric- across it.

Design

Washington D.C. from the time of its initial planning by l'Enfant, through the "City Beautiful" Movement, up to today, has always emphasized the importance of incorporating nature with the built environment, in its urban design. We wish to extend that legacy through the incorporation of the natural -in this case weather and climate- into our design for the proposed Burr-wall by using one of nature's most prolific examples: grass as our model.

We propose a vertical solar collector that interacts with the persistent flows of weather and climate to maximize the generation of solar power and also to generate a constantly changing visual landscape not only producing electricity, but also demonstrating the complex, continuous and entirely unpredictable interaction of building and environment.

Our design takes the form of hundreds of flexible solar "blades" attached at right-angles to the surface of the existing wall. These are supported by a "dynamic net" which not only tensifies the various flows which the solar collectors are both producing and interacting with, but which is also modated by them. The wind blowing through the structure is allowed to deflect it while the newly produced solar power flowing through the cables causes them to rotate. This is achieved through the effect of magnetic fields which occur at regular intervals along the wall, corresponding to the semi-rigid frame structure which supports the net.

In this way we propose to use the electricity generated by the installation to effect the continuous morphological modation of the structure and the dynamic net it supports.

The "blades" would be flexible enough to move and bend themselves while a spring allows them to rotate around their bases, thus responding to the wind blowing through and over the field. The rotation of the cables responds both to the angle of the sun and the amount of current flowing through them and the deflection of the supporting bars is also related to the amount of electricity produced i.e. sun shining. The whole structure would be continuously changing in response to changes in the weather. The solar "grass" blowing in the breeze would be the most obvious of these while the other changes would occur at a slower pace causing variations over days or longer periods -the installation would never look the same way twice.

We are aware that some of the technology in this proposal is experimental in nature but we believe it is crucial to challenge the PV and construction industries to produce new types of net. By posing problems such as these we believe that innovative solutions such as those currently used by the military or space programs (e.g. the military's use of "fabric" in place of glass in their development of the Iridigo portable PV array, UniPac 10) can be developed for Building Integrated PV's. Up to now thinking has been very conventional so only conventional solutions are available. The D.A.R.'s annual project represents, for us a golden opportunity to investigate some innovative solutions for the integration of photovoltaics with architecture.

Technical

Blades

The blades would be covered with flexible amorphous-silicon photovoltaic cells. R&D has shown amorphous-silicon Copper-Indium-Gallium-Selenide (CuInGaS) of up to 18.8% for this type of cell and this would be used in Uni-Solar flexible. Both these types of PV can be very thin (down to 1 micron thick) and could be fixed to flexible stainless steel strips and covered with a film the surface (for example Teflon by Dupont) which eliminates the need for any glass. One of our priorities is to comprehensively explore the possible use of new materials in the installation.

These blades would be attached to the cables by means of CAA-modated cast-steel attachment pieces (as shown in the details which are in two halves with the seals clamped between). A flexible spring connecting the upper half of the assembly and the actual PV blade allows the blade to rotate in any direction while maintaining the base position of 90° to the axis of rotation of the cable. Some rigidity is provided to the base of the blade by a third cast piece which fits over the spring assembly.

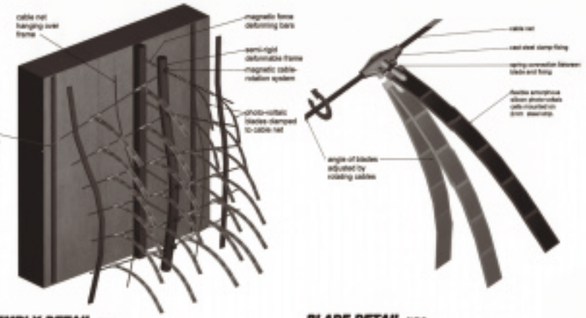
Support Structure

The blades are attached to steel cables which are designed to allow current flow along their length and into the hydrogen grid. These cables are supported of the existing wall at regular intervals by semi-rigid bars with a cellular magnetic core. The flow of electricity in the cables through the magnetic fields thus generated would cause the cables to rotate in an effect similar to that produced by an electric motor. By combining programmed information about the sun's position along with the quantity of electricity flowing through the system the angle of the blades can be adjusted directly or while minimizing exposure to the sun or to reduce it in order to minimize overheating of the cells. The semi-rigid bars are themselves, in turn, deflected in direct proportion to the amount of electricity flowing through their magnetic fields.

The blades would thus be flexible enough to move and bend themselves while the spring allows them to rotate around their bases, thus responding to the wind blowing through and over the field. The rotation of the cables responds to the angle of the sun and the amount of current flowing through them and the deflection of the supporting bars is also related to the amount of electricity produced i.e. sun shining. The whole structure would be continuously changing in response to changes in the weather. The solar "grass" blowing in the breeze would be the most obvious of these while the other changes would occur at a slower pace causing variations over days or longer periods -the installation would never look the same way twice.

electrical current in magnetic fields

electrical current induces cables through spinning magnetic force



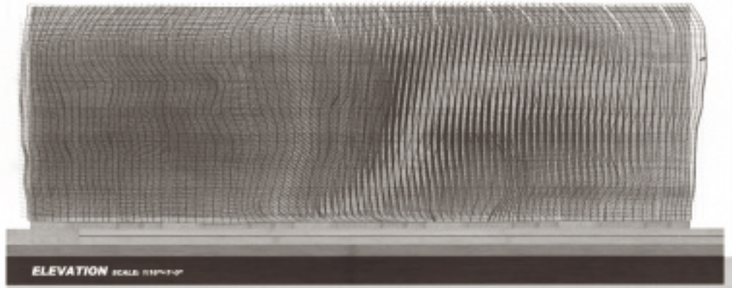
ASSEMBLY DETAIL N.T.S.

BLADE DETAIL N.T.S.

PLAN DETAIL SCALE 1"=1'-0"

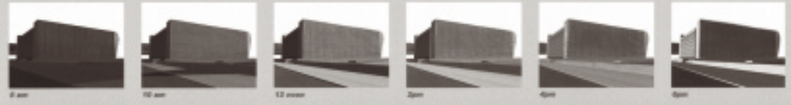
SECTION DETAIL SCALE 1"=1'-0"

PLAN SCALE 1"=1'-0"



ELEVATION SCALE 1"=1'-0"

SECTION SCALE 1"=1'-0"



the changing light, the wind moving the blades, the net responding to wind and electric current -all combine to create an ever-changing landscape

JOHN LEE/MICHAEL TIMCHULA ARCHITECTS
JOHN M. Y. LEE
YING LEE
KIORI MIKAGI
MICHAEL TIMCHULA
ERICH WEFING
HYUNSUK YU

PROJECT NUMBER: 327

TREES SUPPORTING ROOF STRUCTURE

JURY COMMENTS

"In this design where the panel has sort of slipped off the wall, you have the combination of being extremely factory-made and standard, yet it has this life cycle where it slipped off the wall and in the process optimized its configuration for collecting solar energy."

"We talked about that one quite a lot. Even though it's not technically a wall anymore, it collects more solar energy in its roof-like orientation. But then in the end, of course, it was a wall we were looking for."

SUNWALL

Solar energy is an exciting resource that remains largely untapped. Our project proposed to not only exhibit the usefulness of solar energy collection, but reflect the dynamic nature of the solar process. We chose a form for our "Sunwall" that would energize and complement the surrounding architecture, while creating a space within the city that draws attention to and educates about solar energy.

The space created beneath the solar roof would be used as a daycare center and playground for 150 children, including a potential carousel for public use. The roof is transformed from a wall to a canopy that provides passive shading and active solar energy. The different angle of the sun during the various seasons provides for different efficiencies of the photovoltaic panels. Our roof will constantly change due to the variety of panel angles included in our structure.

Energy levels will be indicated on the building by the rising sun and waning moon. At its peak the roof will produce 430 kW of energy/day. The average American household consumes 10 kW/day. One hundred kilowatts of energy will be fed back into the Department of Energy's Forrestal Building, and the remainder will be split between the daycare center, carousel, and the sun/moon display.

SUNWALL • JOHN LEE / MICHAEL TIMCHULA ARCHITECTS

SUNWALL

Solar energy is an existing resource that remains largely untapped. Our project proposes to not only exhibit the usefulness of solar energy collection, but reflect the dynamic nature of the solar process. We chose a form forever 'Sunwall' that would integrate and complement the surrounding architecture, while creating a space within the city that draws attention to and educates about solar energy.

TRANSFORMATION

ROOF PLAN

SOUTH ELEVATION

WEST ELEVATION

EXISTING PLAN TO REMAIN 1'-0"=1/64'

DAYCARE ABOVE EXISTING

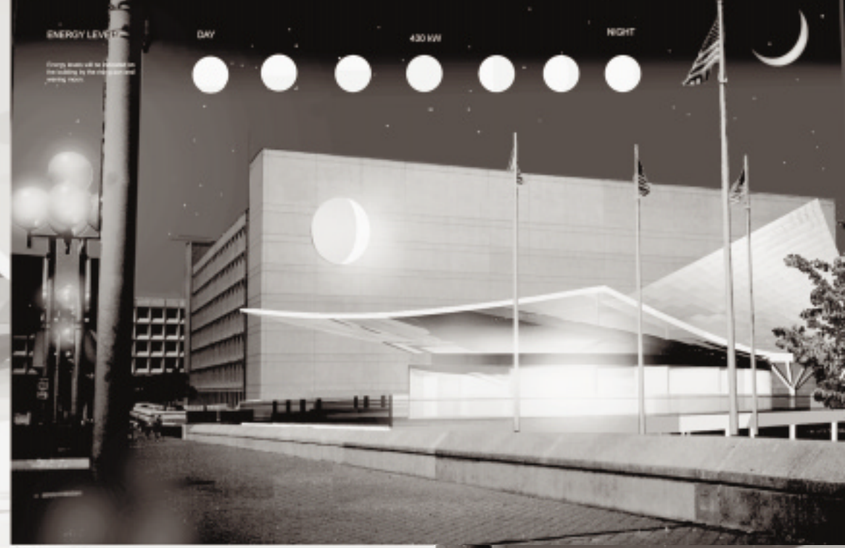
TREES SUPPORTING ROOF STRUCTURE

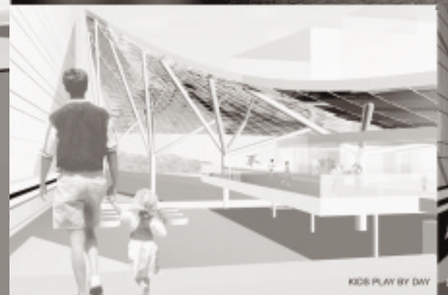
DAYCARE

The space created beneath the solar-roof will be used as a daycare center and playground for the children, including a public, but secured for public use. All will be powered by solar energy.

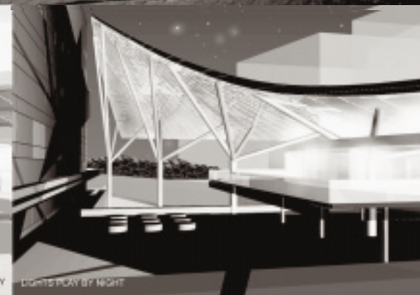
The different angle of the sun during the various seasons, provides for different efficiencies of the photovoltaic panels. Our roof will constantly change due to the variety of panel angles included in our structure.

SEASONAL EFFICIENCY





KIDS PLAY BY DAY



LIGHTSHOW AT NIGHT

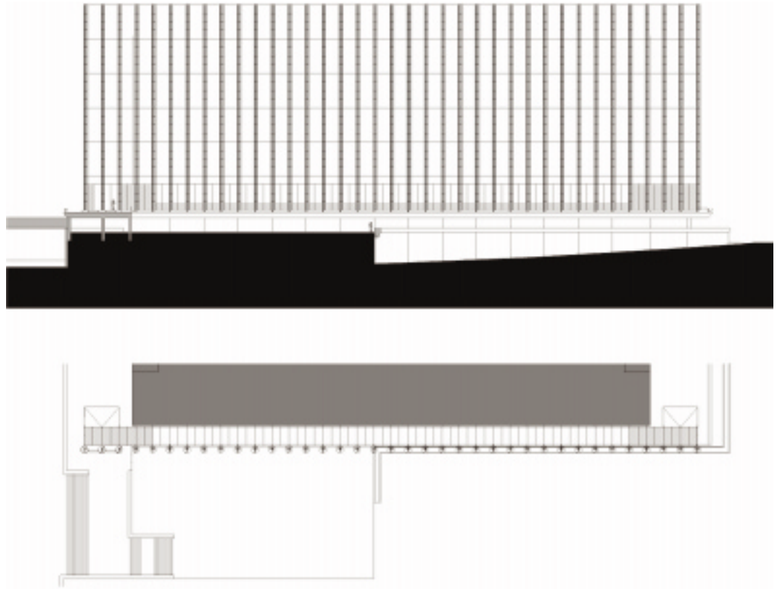
THOMAS PHIFER AND ASSOCIATES
CHRISTOPHER TIMM
THOMAS PHIFER

CARPENTER/NORRIS CONSULTING
JAMES CARPENTER
DAVID NORRIS

JCDA
JAMES CARPENTER
RICHARD KRESS
VALERIE SPALDING

OVE ARUP & PARTNERS, NEW YORK
MATT KING
NIGEL TONKS

PROJECT NUMBER: 460



Sunwall

The Sunwall is meant to produce a dynamic and changing representation of light and a tangible public example of what a solar-based, 21st-century America might be like. The key environmental message of the Sunwall is that electricity can be generated not with coal, or oil, or gas, but with renewable sunlight. Photovoltaic masts rotate constantly and unerringly to follow the sun, harvesting its power 20 percent more efficiently than a static array. Placing the photovoltaic array on masts set outboard of the walkway allows photovoltaic technology to explore its potential to define and enclose architectural space on a more human scale. Visitors can stroll along in a horizontal glass walkway, where they can experience the technology up close. Visitors can explore the masts' dynamic rhythm of light and shadow and immerse themselves in an atmosphere of reflected colored light.

Technical Description

The Sunwall comprises 1,776 photovoltaic modules (Siemens SR100) mounted vertically on 37 masts. Each mast carries 48 modules arrayed in two columns of 24. The array extends beyond the perimeter of the Forrestal Building's south wall, both horizontally and vertically. The masts, which adjust constantly to follow the sun's azimuth, are set outboard of and spaced along the Forrestal's south walkway to permit pedestrian traffic behind them. The photovoltaic modules are connected in series and their harvested electricity is sent to a grid-connected subpanel by way of a combiner box, inverter, and transformer. It is predicted that the Sunwall will produce over 170,000 kWh of electricity annually.

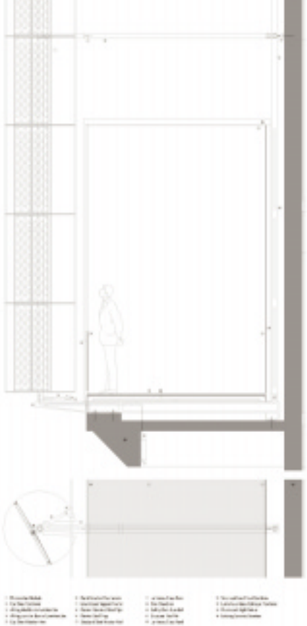
JURY COMMENTS

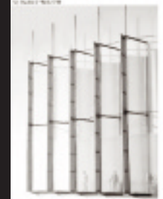
"There's something about the vertical, articulated line. It really is a minimalist sculpture, actually. ...The solar vertical panels picked up on the expression of classical proportions..."

"It's the one that has the most pronounced overlap. It extends beyond the building, which would draw you up the L'Enfant Promenade because you would see at least the last two or three of those fins from down Independence Ave. And it also extends over the top of the building..."

HONORABLE MENTION

SUNWALL • THOMAS PHIFER AND PARTNERS

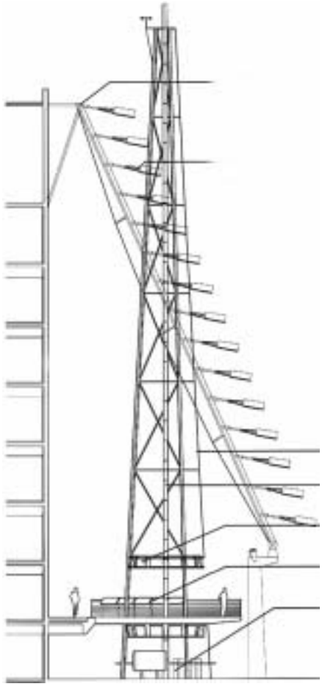




URBAN INSTRUMENTS
DAVID WIBORG
WELLEINGTON REITER
GREG RUSSELL
SARAH WOHLERS

PROJECT NUMBER: 463

8



SUNWALL

Introduction

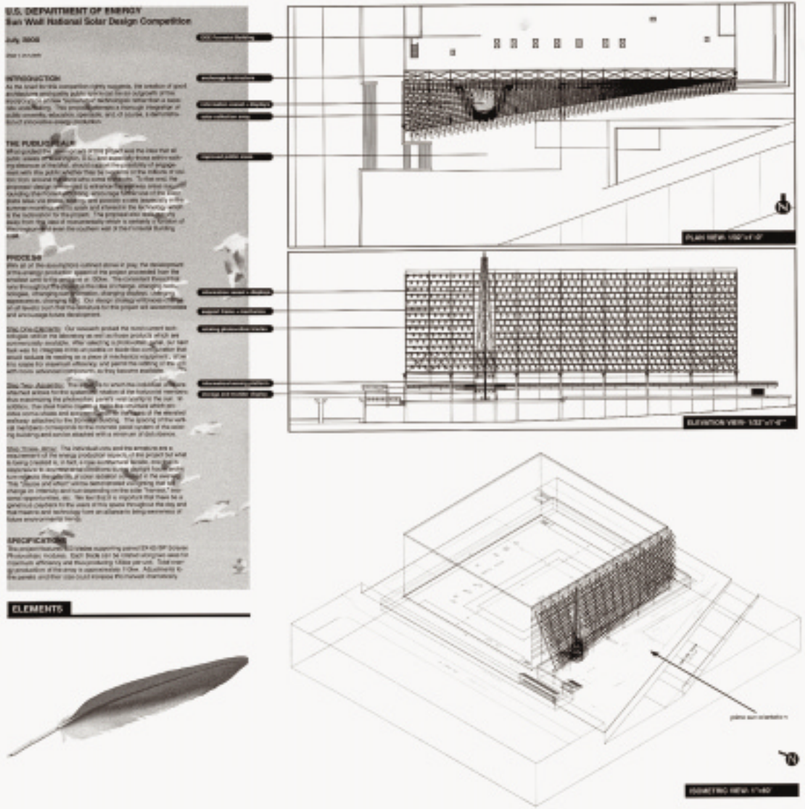
The creation of good architecture and quality public space can be an outgrowth of the incorporation of new sustainable technologies rather than a separate undertaking. This proposal attempts a thorough integration of public amenity, education, spectacle, and of course, a demonstration of innovative energy production.

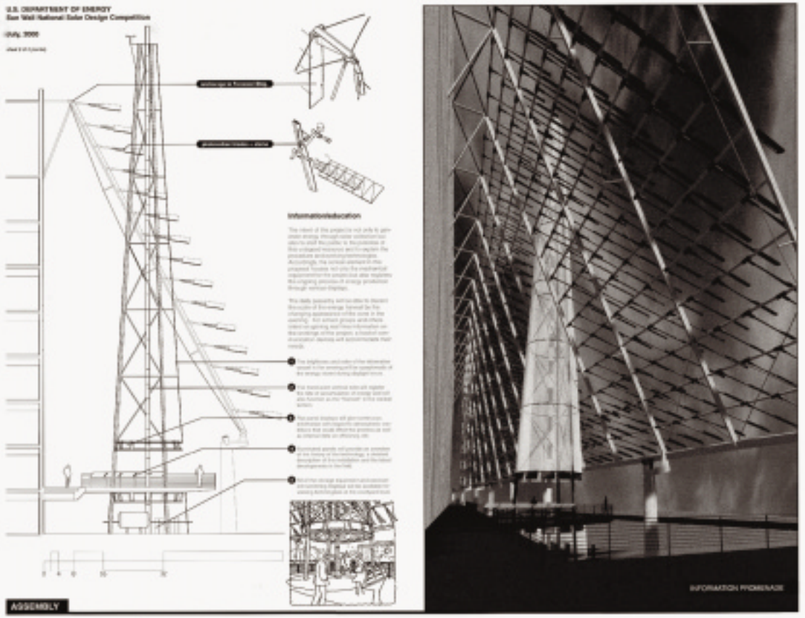
The Public Realm

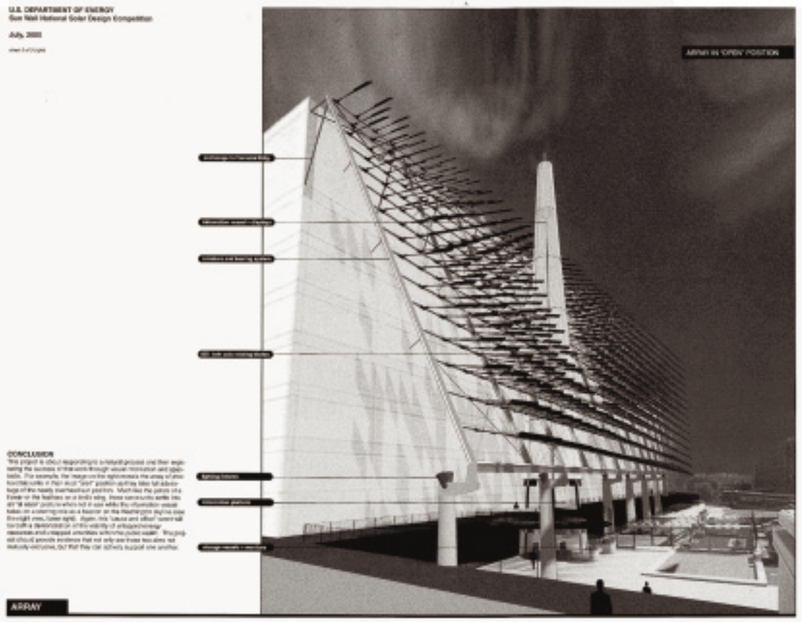
What guided the development of this project was the idea that all public areas of Washington D.C., and especially those within walking distance of the Mall, should support the possibility of engagement with the public whether they be residents or the millions of visitors from around the world who come to the city. To that end, the proposed design is intended to enhance the walkway areas surrounding the Forrestal Building; encourage further use of the lower place areas via shade, seating, and possibly a café (especially in the summer months); and spark an interest in the technology, which is the motivation for the project. The proposal also does not shy away from the idea of monumentality, which is certainly a function of Washington and even the southern wall of the Forrestal Building.

Conclusion

This project is about responding to a natural process and then registering the success of that work through visual information and spectacle. For example, the image on the right reveals the array of photovoltaic units in their most “alert” position as they take full advantage of the nearly overhead sun position. Much like the petals of a flower or the feathers on a bird’s wing, these same units settle into an “at ease” posture when not in use, while the information vessel takes on a starring role as a beacon on the Washington skyline (see the night view, lower right). This “cause and effect” event will demonstrate the viability of untapped energy resources and untapped amenities within the public realm. This project provides evidence that not only are these two aims not mutually exclusive, they can also actively support one another.


U.S. DEPARTMENT OF ENERGY
Sun Wall National Solar Design Competition
July, 2000
INTRODUCTION
THE PUBLIC REALM
PROCESS
SPECIFICATIONS
PLAN VIEW
ELEVATION VIEW
ISOMETRIC VIEW
ELEMENTS


U.S. DEPARTMENT OF ENERGY
Sun Wall National Solar Design Competition
July, 2000
Information/education
ASSEMBLY
INFORMATION PROMENADE


U.S. DEPARTMENT OF ENERGY
Sun Wall National Solar Design Competition
July, 2000
ARRAY IN "OPEN" POSITION
CONCLUSION
ARRAY

PLAZA VIEW OF INFORMATION VISUAL and MEDIA ARCHES

ARRAY in "CLOSED" POSITION with LIGHTING DISPLAY

SAVANNAH COLLEGE OF ART AND DESIGN
CAROLINA LLOVERAS
CATHERINE M. TABOR (FACULTY)

PROJECT NUMBER: 96

Concept Proposal: Patterns in Time / Fractal Vines

Something of elegance and simplicity, something of beauty and timelessness, something that merges the peak of our technological prowess and artistic craft: this is our offering for the Sunwall design competition.

This project shows the possibility of creating beauty through technology by integrating photovoltaics into a building façade. The moving and dramatic use of translucent colored glass PV panels and standard PV panels is both an experiential sculpture and an elegantly functional use of photovoltaic technology.

Our design has three basic components: fractal vines, wall backdrop text panels, and tree canopies.

The main concepts for the form came from nature's models for photosynthesis. We sought to draw a parallel between photosynthesis and photovoltaics. In essence, we focused on a biomimetic approach by looking at vines and how they grow up the sides of trees. We chose fractals because we wanted the system to be modular and composed of basic components.

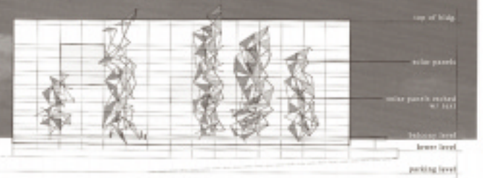
The "tree canopies" are located in the existing parking area and will shade car parking and generate electricity for electric car charging stations located below the canopies.

The final result is a wonderful experience of walking through a mosaic of kite-shaped panels, together creating a fabric, a texture, a pattern of color, and shadows emulating nature.

doe sunwall

Look: the sun has spread its wings over the earth to dispel the darkness.

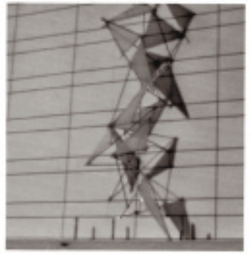
Like a great tree, with its roots in heaven, and its branches reaching down to the earth.



aesthetic challenge:

The technology of photovoltaics is a beautiful expression of science. The blank canvas is "painted" with colored light through the use of **color tinted glass** combined with **translucent PV panels**. The result is light passing through the translucent panels creating **shadows and streams of colored light.**

It was important to respect the past, and in so we "walked" lightly on the existing grounds. The new structure ties into the old in a **delicate connection**. The grid of the original building facade design was not altered. The structure is the mediator between the old and the new, providing a balance, bridging the two.



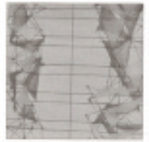
the sense of aliveness was a desired expression.

How can a solid blank wall mimic nature and become alive?

Seeking a precedent, the example was found in nature in the simple **vine which climbs the wall** or tree **seeking the light**. It engages a place to grow and live against the odds. The concept of "fractal vines" was developed to realize this. The context offers a nearby rail line with existing graffiti, which inspired the use of the DOE wall to inform in an expressive way the passion of the sustainable movement in architecture and society.

fractal patterns

"Everything that nature makes, nature records how it was made."

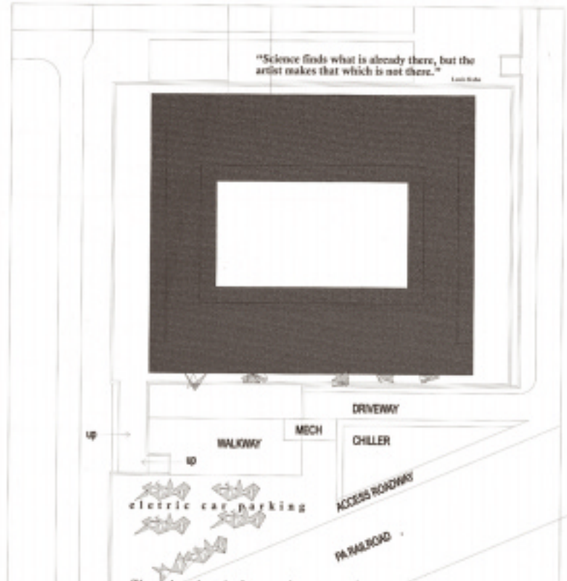


satellite photo from 500 ft.
Washington D.C.
38 degrees 45 minutes

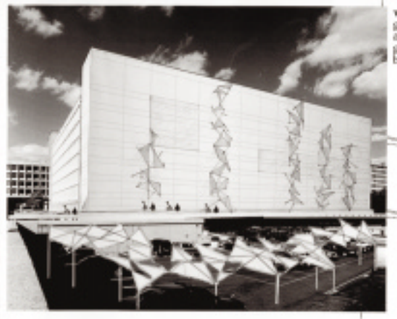
" We must draw our standards from the natural world. We must honor with the humility of the wise the bounds of that natural world... admitting that there is something in the order of being which evidently exceeds all our competence."

Wall aesthetics
communicate to inform
railroad and the graffiti artist
translucent panels etched with text
as living parts of buildings

"Science finds what is already there, but the artist makes that which is not there."



The solar electrical power is generated by translucent panels which cast colorful shadows on the blank canvas of the white wall.
Solar electrical power is also generated from the **PV canopies** which shade the parking area. These canopies provide electrical power for the **electric auto parking and charging station** located below.



vines
grow up walls
a system
grabbing into the joints
between the stones

wedged kite shaped
marmble mosaic of
panels.
various sizes creating
a fabric.

solar technology:

Solar panels- translucent material 1/2" single crystalline (product: Atlantis Energy) modified to be paired with 1/2" colored tempered glass with 1/2" single crystalline panels, are connected with bolts. No frame around the colored glass is used.

The result is an efficient translucent panel applied to a stainless steel armature, also used as conduit for electrical wire hook-up from solar panels to one of the 6 inverters located on the roof.

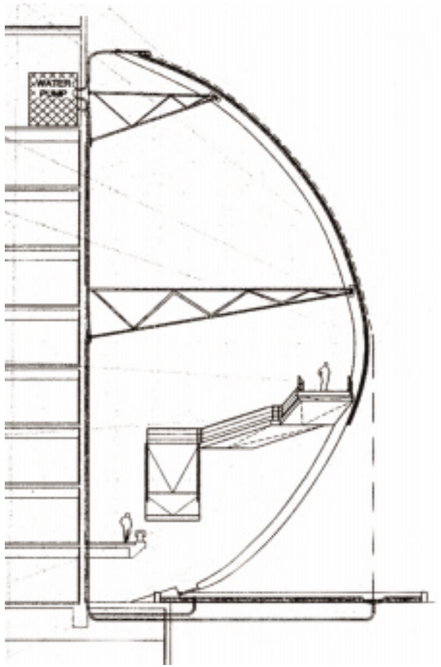
shadows
constant changing
shapes left over from the sun's acknowledgment
of existence
solar time, watch the wall varying over time
and season shadows, stretching, high and low.

How is it to be there?
Walking among the delicate sculptural panels below the delicate colored cast shadows allows us to participate in the beautiful expression of nature, science and art.

6 - 21 nine noon six

UNIVERSITY OF VIRGINIA
MARK HAIZLIP
BRANDON JOO
KRIS CONNER

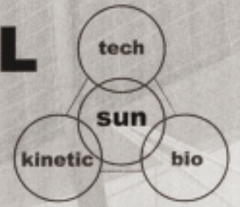
PROJECT NUMBER: 294



SUNWALL

In response to the sun's arc through the sky, the wall takes the form of a curve in both plan and section. This maximizes the surface's exposure to the sun's direct and most potent radiation, thereby maximizing energy output. On a human scale, this hemispherical structure forms an inhabitable space, visually suspended off the wall. A ramp gradually climbs through the expanding and contracting boundaries and sets the experience in motion, occasionally pausing for a moment of light, and terminating at an observation deck that pierces through the enclosing skin into the brightness of the sun, a point of reflection. A waterfall continues the kinetic sense of the composition, travelling up the existing wall through exposed pipes and falling with gravity over the taught skin to a shallow pool at the ground level. The sun generates the form and function of the design in every aspect—from the complex curve that favors the south-east in plan and tilts slightly skyward in section, to the abstract idea of kinetic energy and motion, to the literal electricity required to move water against the gravitational force of the earth. Producing approximately 200 kW of electricity, the construct harnesses enough energy to sustain its own cycle of kinetic/potential energy, and it assists with the primary energy requirements of the building.

D.O.E. SUNWALL



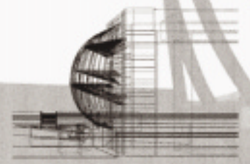
energy cycles

-EFFICIENT CAPACITY FOR SOLAR COLLECTION

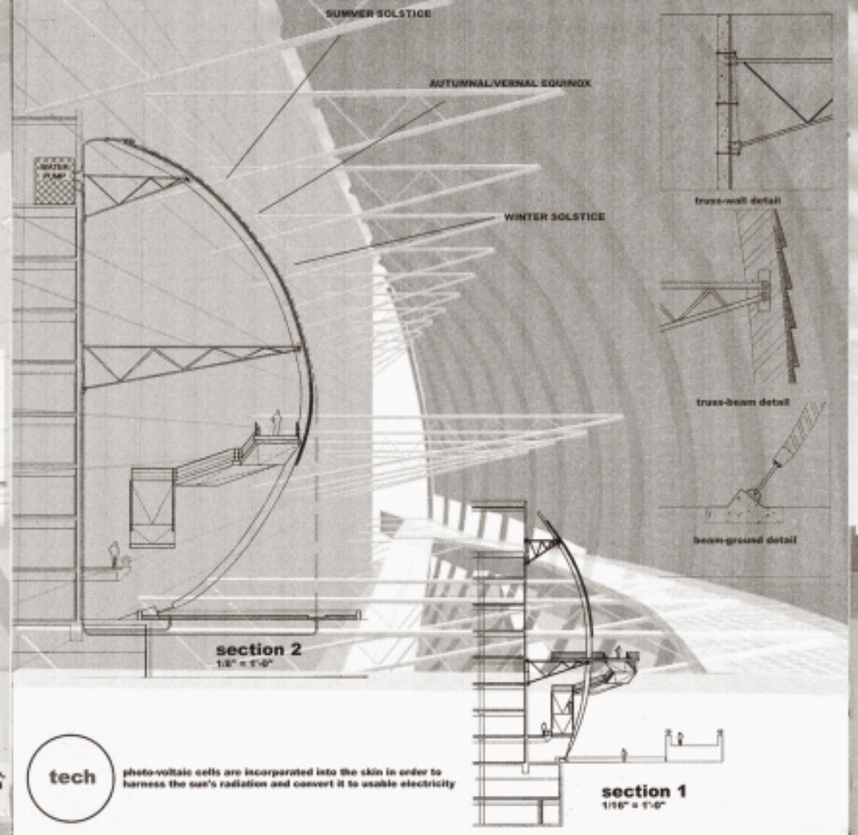
-AESTHETIC, KINETIC, AND ENVIRONMENTAL AWARENESS

-CREATION OF PUBLIC SPACE

elevation
1/32" = 1'-0"



kinetic motion: people move through modulated and distorted space, while water moves in a constant cycle both of accepting and resisting gravity.



section 2
1/8" = 1'-0"

section 1
1/16" = 1'-0"

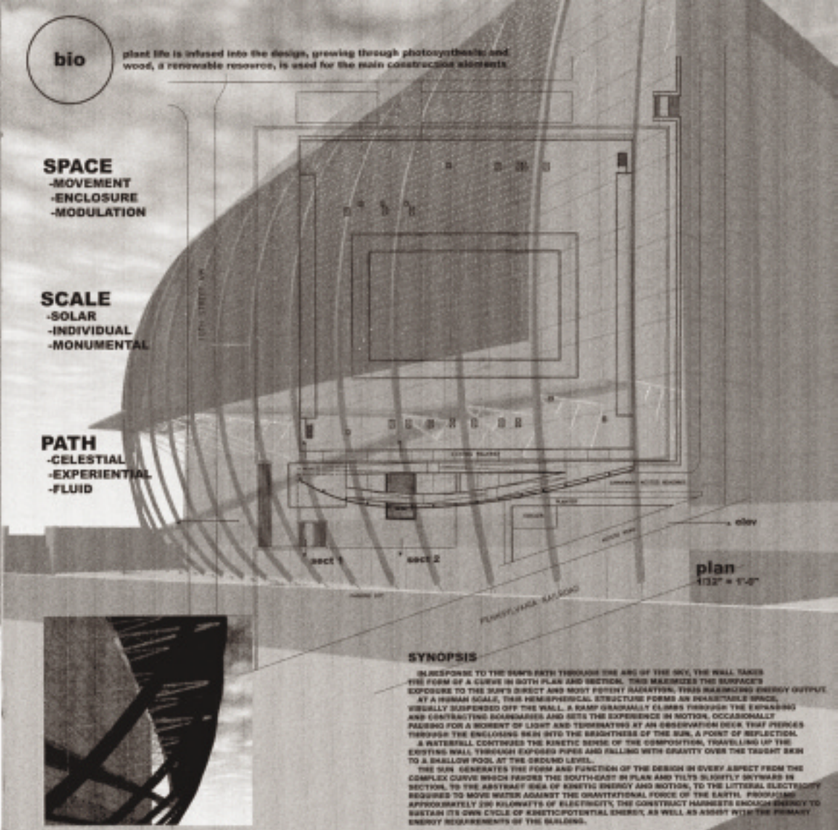
tech photo-voltaic cells are incorporated into the skin in order to harness the sun's radiation and convert it to usable electricity

bio plant life is infused into the design, growing through photosynthesis and wood, a renewable resource, is used for the main construction elements

SPACE
-MOVEMENT
-ENCLOSURE
-MODULATION

SCALE
-SOLAR
-INDIVIDUAL
-MONUMENTAL

PATH
-CELESTIAL
-EXPERIENTIAL
-FLUID



plan
1/32" = 1'-0"

SYNOPSIS

IN RESPONSE TO THE SUN'S PATH THROUGH THE ARC OF THE SKY, THE WALL TAKES THE FORM OF A CURVE IN BOTH PLAN AND SECTION. THIS MAXIMIZES THE SURFACE'S EXPOSURE TO THE SUN'S DIRECT AND MOST POTENT RADIATION, THUS MAXIMIZING ENERGY OUTPUT.

AT A HUMAN SCALE, THIS HEMISPHERICAL STRUCTURE FORMS AN INHABITABLE SPACE, VISUALLY SUSPENDED OFF THE WALL. A RAMP GRADUALLY CLIMBS THROUGH THE EXPANDING AND CONTRACTING BOUNDARIES AND SETS THE EXPERIENCE IN MOTION, OCCASIONALLY PAUSING FOR A MOMENT OF LIGHT AND TERMINATING AT AN OBSERVATION DECK THAT PIERCES THROUGH THE ENCLOSING SKIN INTO THE BRIGHTNESS OF THE SUN, A POINT OF REFLECTION.

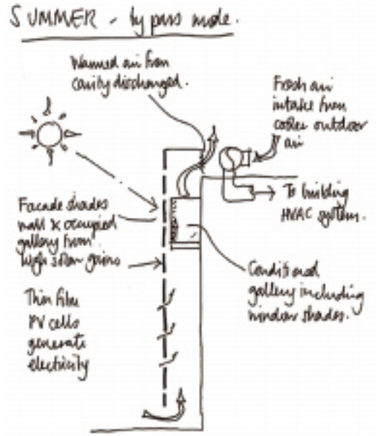
A WATERFALL CONTINUES THE KINETIC SENSE OF THE COMPOSITION, TRAVELLING UP THE EXISTING WALL THROUGH EXPOSED PIPES AND FALLING WITH GRAVITY OVER THE TAUGHT SKIN TO A SHALLOW POOL AT THE GROUND LEVEL.

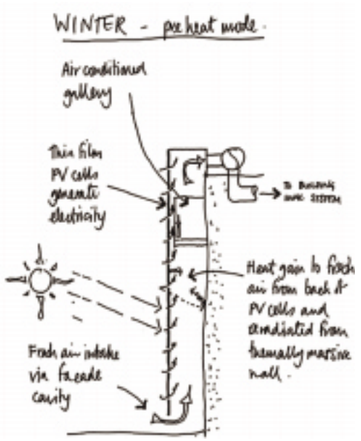
THE SUN GENERATES THE FORM AND FUNCTION OF THE DESIGN IN EVERY ASPECT FROM THE COMPLEX CURVE WHICH FAVORS THE SOUTH-EAST IN PLAN AND TILTS SLIGHTLY SKYWARD IN SECTION, TO THE ABSTRACT IDEA OF KINETIC ENERGY AND MOTION, TO THE LITTERAL ELECTRICITY REQUIRED TO MOVE WATER AGAINST THE GRAVITATIONAL FORCE OF THE EARTH. PROVIDING APPROXIMATELY 200 KILOWATTS OF ELECTRICITY, THE CONSTRUCT HARNESSES ENOUGH ENERGY TO SUSTAIN ITS OWN CYCLE OF KINETICPOTENTIAL ENERGY, AS WELL AS ASSIST WITH THE PRIMARY ENERGY REQUIREMENTS OF THE BUILDING.

KISS + CATHCART
GREGORY KISS
COLIN CATHCART
FLORIAN BAUER
KIMBRO FRUTIGER
ROBERT GARNEAU
NURIA WIDMANN
PEGGY MOCK

OVE ARUP & PARTNERS USA
DAVE RICHARDS
PETE TILSON

PROJECT NUMBER: 370





SUNWALL

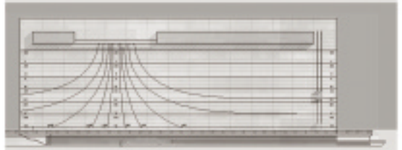
Solar energy technology is inherently silent and self-contained. Desirable as these qualities are for a power source, they make photovoltaic production invisible to the casual observer. Kiss + Cathcart's design not only produces energy both actively (PV electricity) and passively (heat collection), it also reveals the work of solar technology through the sunlight it transforms.

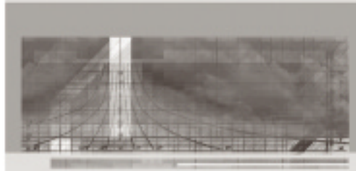
The proposed solar surface is a city-scaled sundial, with light passing through a PV screen to mark time on the concrete wall. The glass screen incorporates crystalline and thin-film panels with various translucencies, and the space behind is animated by various diffusions of light pierced by the bright shaft of the sundial and the gnomon's shadow. The sundial manifests the dynamism and the dependability of the sun and of energy derived from it.

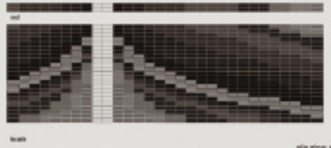
The PV surface is set eight feet out from the face of the DOE building, with a building-integrated PV enclosure along the top of this slot housing an educational exhibit. After an account of solar energy's development, visitors cross the sundial cut into a room that features an enormous digital output display visible from the street.

The Sunwall comprises a photovoltaic assembly and a thermal collection system. The PV array consists of 4' x 10' BIPV modules in 10 degrees of translucency. The more opaque modules are custom-scribed amorphous silicon. The more transparent modules incorporate monocrystalline silicon wafers laid out in a grid pattern. The total size of the system is 113 kWp.

SUNWALL • KISS + CATHCART ARCHITECTS







SUNWALL I

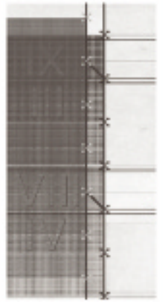
Solar energy technology is inherently silent and self-sustained, harmless, easy-to-site – remarkable as this for a power source – actually discourse the competition between photovoltaics, installations and the work they do. Two systems we have designed will produce energy both actually (PV-electricity) and poetically (heat collection), but have positions virtually invisible presences for contrast to this natural element.

Our proposal distills the action of solar technologies into a simple, day-activity of the sunlight a to-phase. This will be accomplished by:

a a vertical landscape and
a an output display-display.

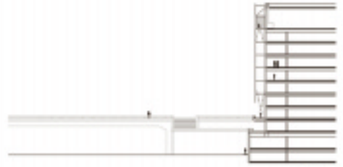
The solar surface is a sky-scaled material, with light passing through a PV (electric-distribution as the concrete-rail). The glass screen (formation-the flexibility of current PV technology for shifting, intermittency near do-sought, it will incorporate both a positive-positive-fabs, panels, taking advantage of their variety visual transparency. Thus, the solar transparency will allow interior space, both visible and transparency, and allow diffusions of light and photo-for the bright shell of the corridor.

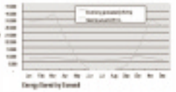
The vertical image captures both the characteristic and the regularity of the sun – and energy-derived branch.



The sunwall comprises two energy-generating systems: a photovoltaic assembly and a thermal-collector system. The PV using cut-outs of 4" x 18" BIPV-modules has degrees of transparency. The more opaque modules are arranged on silicon, custom-perfect in a pattern-to achieve light transmission. The more-transparent modules incorporate a-lamination silicon wafers, laid out in a grid pattern on carbon substrate.

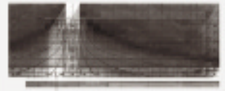
The total size of the sunwall is 1500ft2.

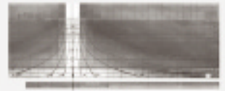


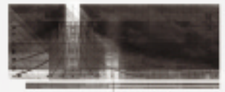


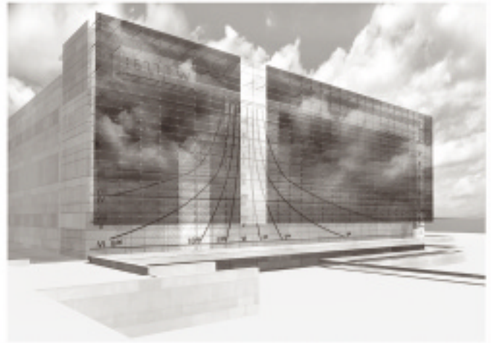
SUN WALL BOARD I TECHNICAL DATA

national design competition at the Department of Energy Washington, DC







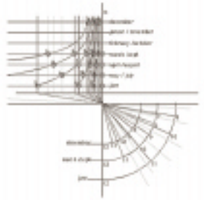


The PV surface is an light box sunlines thickness of the existing building, creating an opportunity for two building-integrated PV enclosures. We propose an educational exhibit in a lightweight structure along the top of this site, mounted by a glass structure.

The exhibit will inspire with an aspect of solar energy's development. Visitors then pass the sunwall-to the PV screen and water screen that describes the Sun Wall Collector and features an hands-on solar-digital output display, visible from the street.

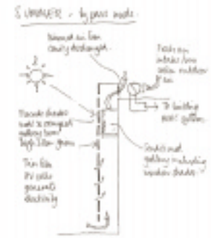
Plantings in the exhibit area will provide shade and improve air quality – another manifestation of solar energy. Part of this space could display given over to DOE-wide sponsorship within the existing building.

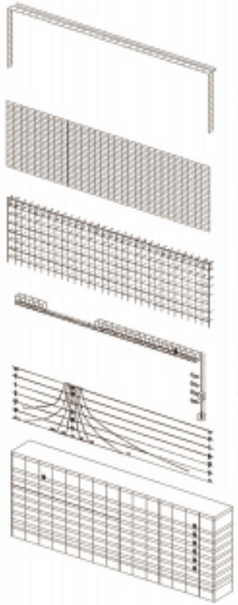
People and presence will be visible through the PV glass surface, stimulating the interest of drivers and pedestrian-factors.



SUN WALL BOARD I I PRINCIPLES

national design competition at the Department of Energy Washington, DC





thermal collector

glass between the dark-coloured PV modules acts as a single-order transparent-absorber-storing-heat-collector-slab space

PVs

BIPV modules incorporated-transparencies, cover the exhibition-built wall and the horizontal roof area

structure

the BIPV modules are hung from steel-blade supports-by-tripod-elements at the top. The blade-elements-tend back to the existing facade by-stays at 12° to 15 degrees. The system is braced horizontally by cables

exhibition

a collector leaves the public and DOE employees in the-wall gallery behind the upper PV wall. An exhibition of the battery-shaker technologies is followed by a-interactive-display of the DOE sponsored solar systems.

sundial pattern

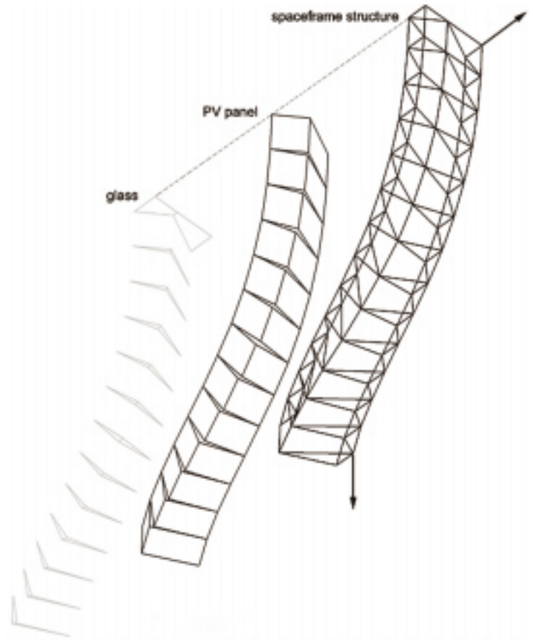
stainless steel bars allowed to the existing building track-solar time throughout the year

SUN WALL BOARD III CONSTRUCTION

national design competition at the Department of Energy Washington, DC

MOTONOBU KUROKAWA

PROJECT NUMBER: 227



URBAN PLEATS

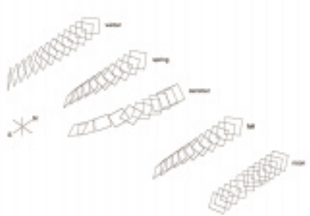
Surface

"The division of the continuous must not be taken as of sand dividing into grains, but as that of a sheet of paper or of a tunic in folds, in such a way that an infinite number of folds can be produced." Pacidus Philalethi (C, 614-15)

Pleats are indelibly "baked" into synthetic fabrics such as polyester, whose thermoplastic properties have a "memory" for heat. Similarly, the proposed design intends to capture the memory of the sun and its translation into the electricity. In the conceptual stage, a series of computer graphic animations demonstrated various organizations of the panels in relation to the sun's movements. By incorporating "time" into the design process, the Cartesian theory of coordinates became obsolete; time collapses space into infinite repetition of folds. The proposed surface, like pleated fabric, folds the trace of sunlight into the urban fabric.

Urban Strategy

The gap between the existing wall and the PV surface is used as a public promenade, connecting 10th Street to Independence Avenue. Dozens of so-called "E-booths" are located on site to provide the public with information such as event schedules, reservations, email etc., via the Internet. The promenade, by definition, is not a destination but a hub connecting multiple destinations. E-booths play a significant role in a virtual promenade by digitally enriching the public's access to the information on where to go and what to do next.

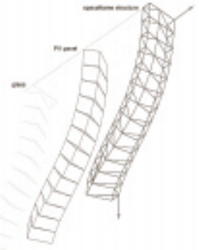


Patternization of Animated form:

By simulating in computer graphic software, a 108 x108 plane is placed perpendicular to the sun where the angle is optimized for the PV system. This plane is animated to follow the sun trajectory of different seasons. As shown on the diagram above, in summer, the panel lays horizontally whereas in winter, it lays vertically.

Vertical landscape:

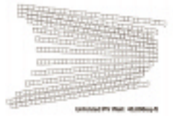
Verticality of the existing facade in the proposed site was taken into consideration. Winter solstices performed a trajectory that produced a set of the most vertical planes. The entire layout was thus selected for further development of Photovoltaic surface.



Organization:

The layout of PV panels was carefully examined so that the panels do not cast shadows to each other all year round. Top portion of the spacetherm leans against the existing building facade, whereas the bottom of the structure sits on the concrete base apart from the wall.

+



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Pleats and Human Anatomy:

Human small intestine unfold 1.5 times tennis court in area. By maximizing its length in folds like pleats, intestine effectively absorbs nutrition. Similarly, the pleated PV surface maximizes sun exposure and increases energy production.

Urban Pleats:

A loop of PV panels was repeated 14 times to cover the width of the existing wall, resulting in 46,000sq-ft of PV facade. Due to its unique organization, the PV surface constantly alters its facets during the day, month and season depending on the position of the sun.

INOUE PLEATS CO., LTD.
Aurelion Bristle, 1998
Polyester. Hand pleated and heat set

URBAN STRATEGY, Introduction of Promenade:

The current condition of the elevated walkway around Forrestal Building is a narrow enclosed loop that is limiting the potential for public activities. In proposed design, the gap between the existing wall and the PV surface is used as a public promenade, connecting 10th street to Independence Avenue. The walkway consists of two wide ramps that allow pedestrians to observe the anatomy of the PV facade at different heights. Underneath one of the ramps is a DOE's employee cafeteria during daytime that also serves as a bar/cafe at night and on weekends. Dozens of so-called **"E-booth"** are located on site to provide the public with information such as event schedules, reservations, E-mail etc. via the Internet. The electricity from the PV panels powers this "E-booth". The rest of the energy is transferred to the utility grid in the existing building.
The promenade, as a definition, is not a destination but is a hub connecting multiple destinations. E-booth plays a significant role in a virtual promenade: digitally enriching the public's access to the information on ***where to go and what to do next.***

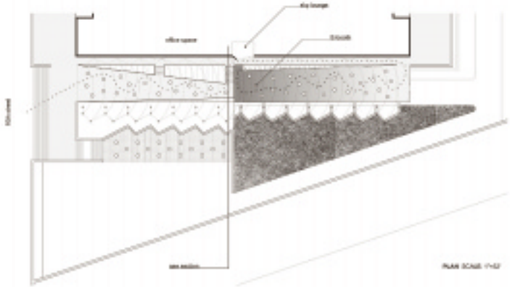
SITE PLAN

CONCEPTUAL DIAGRAM

PV with 20% transparency allows a comfortable level of daylight into the promenade. The sun's rays and the shadows of clouds pass through various objects such as PV panel, glass, and aluminum structure before reaching the existing stonewall. Such obstacles in different transparencies project mosaics of shadows on the wall. The perforations on the existing stone facade become the sky lounges for DOE employees.

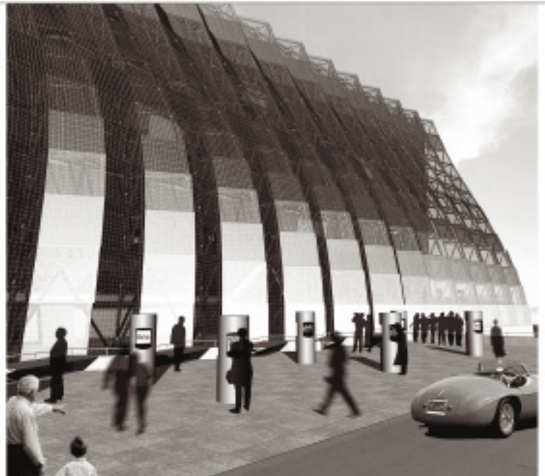
URBAN PLEATS

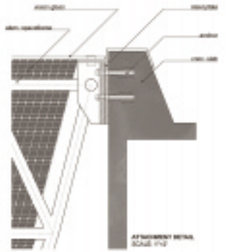
INOUE PLEATS CO., LTD.
Blizzard, 1992
Polyester. Machine pleated



The PV surface constantly alters its facets during the day, month and season depending on the position of the sun.

* See back of this board for energy production calculation/PV panel information.





SURFACE:

"The division of the continuous must not be taken as of seed dividing into grains, but as that of a sheet of paper or of a tunic in folds, in such a way that an infinite number of folds can be produced." Pierre Philippe (C, 614-16)

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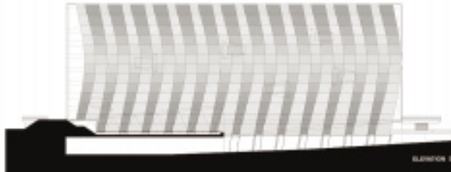
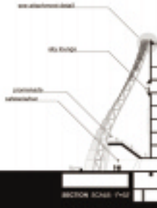


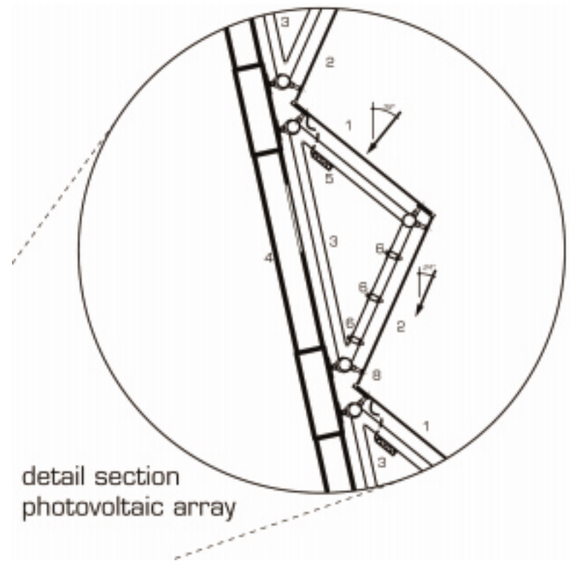
ELEVATION SCALE: 1"=32'



SECTION SCALE: 1"=32'

EVANS HEINTGES ARCHITECTS PLLC
ROBERT EVANS
KEVIN PRATT
SHALINI ABEYARATNE
AYBARS ASCI

PROJECT NUMBER: 396



SUNWALL

Our Sunwall project is a dynamic and visually exciting way of treating an optimal fixed array of photovoltaic cells affixed to a south-facing wall in the Northern Hemisphere. By transforming the simple geometry of the array into a waving United States flag, we hope to demonstrate the plastic opportunities afforded by modern photovoltaic materials. We also intend to create a landmark piece of public sculpture that will draw attention to both emerging solar technology and the many green building programs initiated by the Department of Energy.

To this end, the entire structure will be illuminated by cold cathode tubes at night, expending the energy collected during the day, thus demonstrating the project's electrical potential. The design also incorporates a gallery space behind the point supported glass star field; this will allow both a close examination of the array itself and the staging of small exhibits related to the activities of the Department of Energy.

SUNWALL • EVANS HEINTGES ARCHITECTS

sunwall

PROGRAM

Our **SUNWALL** project is a dynamic and visually exciting way of creating an optimal-fixed array of photovoltaic cells affixed to a south-facing wall in the Northern Hemisphere. By transforming the simple geometry of the array into a waving United States flag, we hope to demonstrate the plastic opportunities afforded by modern photovoltaic materials. We also intend to create a landmark piece of public sculpture that will draw attention to both emerging solar technology and the many green building programs initiated by the Department of Energy. To this end the entire structure will be illuminated by cold cathode tubes at night, expending the energy collected during the day thus demonstrating the project's electrical potential. The design also incorporates a gallery space behind the point supported glass starfield; this will allow both a close examination of the array itself and the staging of small exhibits related to the activities of the Department of Energy.

ARRAY

The array consists of thirteen staggered rows of mono-crystalline silicon laminated photovoltaic panels. The panels are supported on aluminum fittings by curving trusses, which themselves are affixed to massive steel stanchions. The panels are tilted 38.8° ± 1° (the latitude of Washington DC) from the horizontal, maximizing year round insolation. The total area of the panels is approximately 20,000 square feet. Thus, the array will have a peak electrical output of nearly 2MO kilowatts (assuming an output of 11 watts per square foot).

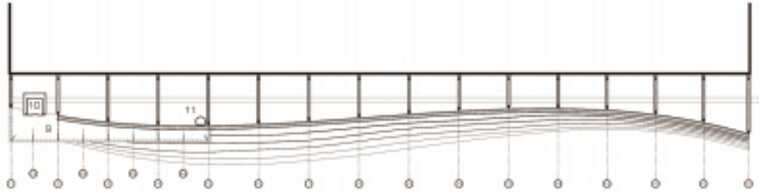
The remaining panels, which form the "stripes" of the flag when seen from below, are tilted 24° ± 1° from the vertical, preventing shadows from affecting the output of the pv panels at any time of the year. The panel itself is point-supported laminated glass with a blue color film interlayer that provides its color and translucency. Behind these panels are cold cathode lighting elements that illuminate the array at night.

POWER USAGE

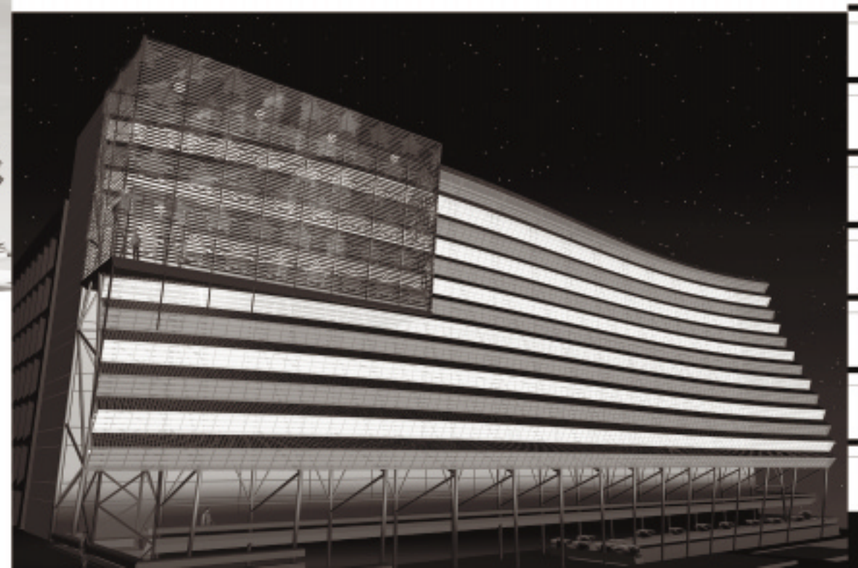
The array is connected to the power grid; it does not use environmentally suspect battery technology. The array's photovoltaic cells feed power to the grid during peak usage times in the middle of the day; the cold cathode lighting elements draw current at low usage times at night, when the sun is not shining.

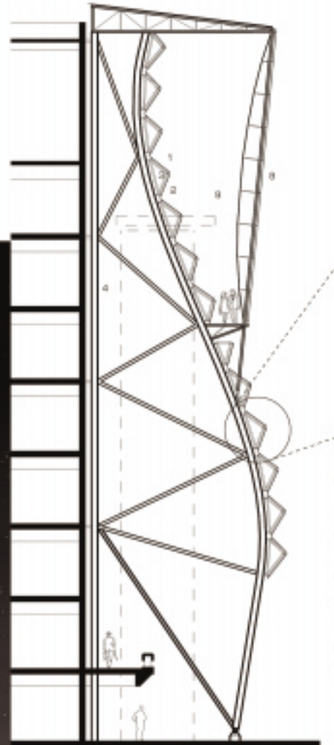
GALLERY

The gallery is enclosed by a point supported laminated glass wall. The laminated lights incorporate a blue film photovoltaic interlayer that provides shading for the gallery space as well generating current to power ventilating equipment. The blue film photovoltaics are combined with a translucent film interlayer that creates the distinctive star pattern visible in the renderings. The gallery is accessible to the public via a hydraulic elevator.

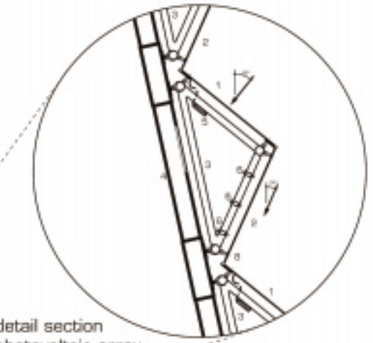


plan



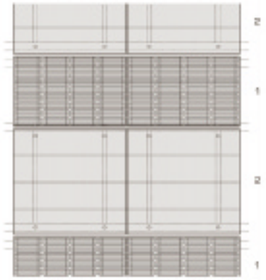


vertical section



detail section
photovoltaic array

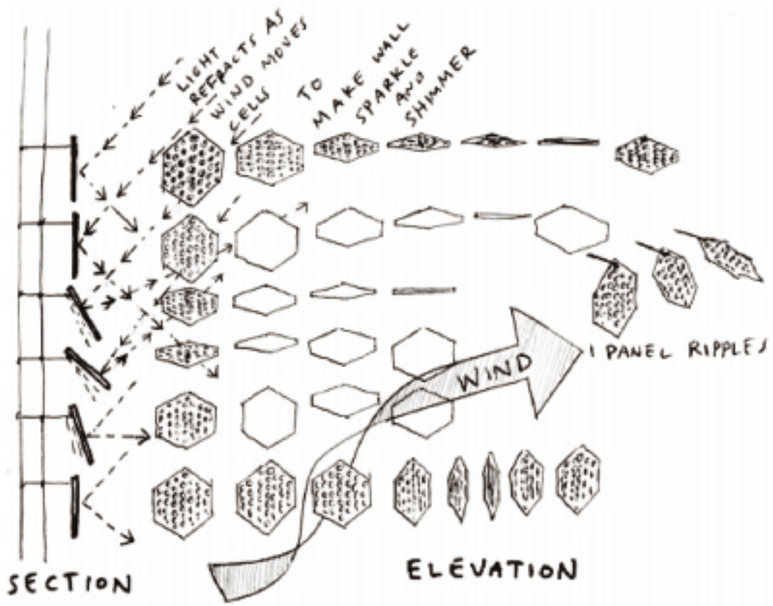
1. laminated pv collector (similar to BP Solarex BP595L)
2. laminated glass (3/16" clear – 0.03 mil mylar film interlayer – 3/16" clear)
3. painted steel truss – 3" c. tubes
4. painted steel stanchion (8" x 1 20 o.c. – laterally brace to existing concrete wall of terrestial building
5. electrical conduit from solar collector to power grid
6. cold cathode lighting element
7. laminated glass with blue film photovoltaic interlayer
8. point support
9. gallery space
10. elevator
11. access ladder



detail elevation
photovoltaic array

STUDIO GANG/O'DONNELL
MARK SCHENDEL
JEANNE GANG
KATHLEEN O'DONNELL
KARA BOYD
JUNNKO GOESKI

PROJECT NUMBER: 232



CONCEPT SKETCH - FLUTTERING MOVEMENT

SOLAR SEQUINS

Solar Sequins was designed to excite and engage visitors with a phenomenal experience that is as changing as the D.C. weather. Solar Sequins move with the wind refracting sparkles of light to create constantly changing patterns across the surface. In this way the environment itself actually defines the aesthetic of the wall and makes the public aware of its presence.

Thirty-six silicon mono-crystalline cells laminated between sheets of low -iron glass make up one "Solar Sequin" or PV module. Six thousand, eight hundred and fifty Sequins are mounted to rods in a three-dimensional lightweight stainless steel cable-net structure. Slight movement is encouraged through a pivoting socket connection. Eye-catching sparkles attract attention to this impressive example of solar energy in the nation's capital.

"Your actions are pointless if no one notices." At night, a projector powered from the wall shines the American text artists' phrases onto the surface (the projected light is recycled by the PV). Like the wall's surface, the text changes periodically to engage frequent visitors.

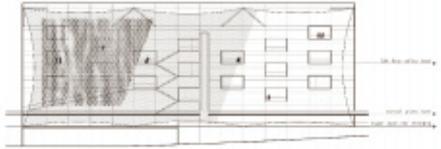
The Solar Sequins project combines architecture, engineering, and art, each informing the other. The tight-knit collaboration makes this project representative of a 21st-century interdisciplinary approach to design.

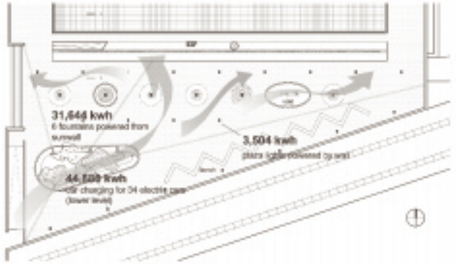
SPACE BETWEEN

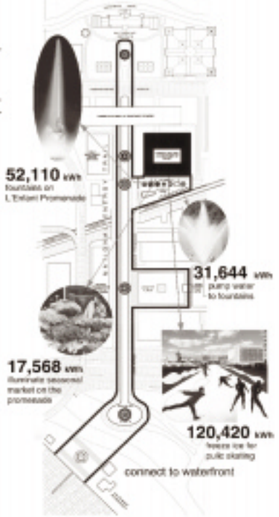
Shadow patterns animate new balconies, patios, and rooms between the diaphanous PV net and the wall. These spaces are structurally supported from the building's diaphragm. Fifteen voids cut into the existing wall (where structurally convenient), improving the DOE office building by providing daylight, air, and views to the otherwise monotonous floor plan. Four public rooms are accessible from the plaza. Visitors move between the various spaces, which offer information about the Sunwall, the new National Energy Trail and its urban amenities, food, refreshments, and a place in the shade. Our project unites the Sunwall and the Forrestal building by activating a dynamic space between the two.

SOLAR SEQUINS • STUDIO GANG / O'DONNELL

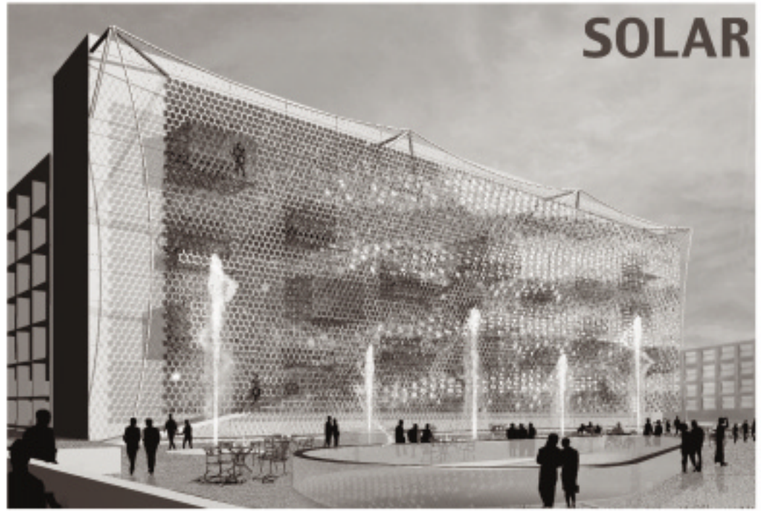
SOLAR SEQUINS

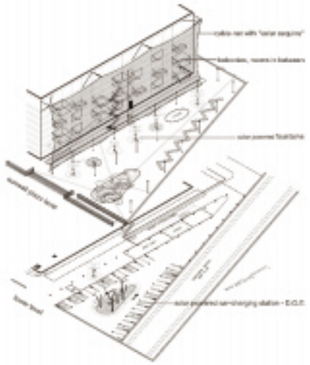


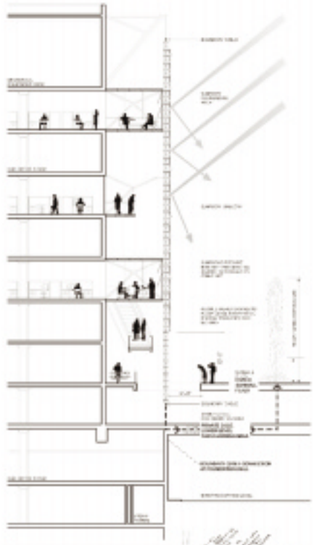


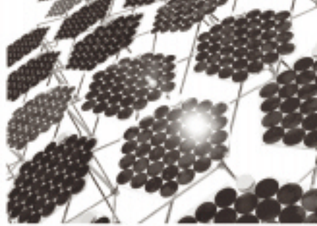


urban amenities powered by sunwall



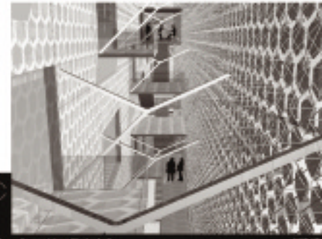






PVC module "solar sequin"

PVC net



the SOLAR SEQUINS:

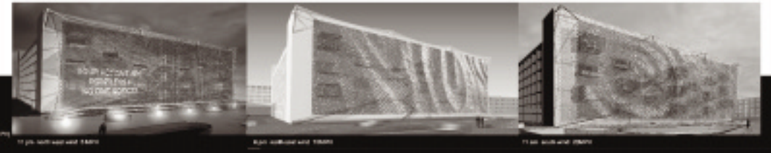
THE WIND MOVES SOLAR SEQUINS CAUSING CHANGING PATTERNS OF REFRACTED LIGHT - A PHENOMENAL EXPERIENCE

the SPACE BETWEEN:

SHADOW PATTERNS ANIMATE NEW BALCONIES, PATIOS, AND ROOMS BETWEEN THE DIAPHANOUS PV NET AND THE WALL.

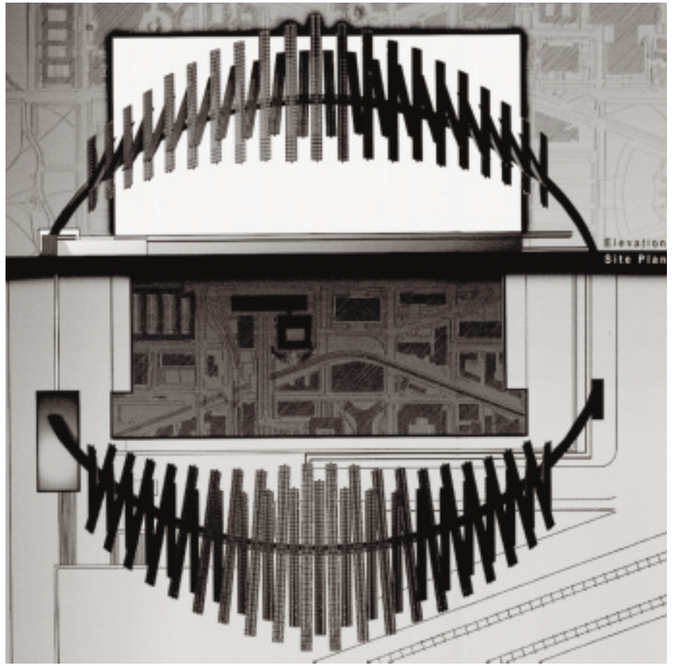
URBAN. INTEGRATED. PHOTO. VOLTAICS.

THE SUN POWERS URBAN AMENITIES FOR THE PUBLIC



DANIEL MANN JOHNSON & MENDENHALL
MARK D. WOODBURN
MIKE FRIEDS
AARON GASPAR
HOWARD KRAVITZ
JEANNIE MA PARISH
REBECCA L. SEITZMEYER
ROBERT R. SMEDLEY

PROJECT NUMBER: 320



MISSION

This solar sculpture is intended to make three primary contributions. First, the design seeks to create a major architectural and technological landmark via implementing design concepts of the solar system. The landmark status leads to the second contribution of raising public awareness (education) about solar energy as the design is based upon the essential aspects of the solar system. And third, while the sculpture is a fixed element of uniqueness in its own right, the resulting shadows cast upon the +32,000-square-foot canvas of concrete will provide an enduring selection of varied compositions. This once bleak wall of sameness will be transformed into a living wall of perpetual change.

CONCEPT

The Sunwall is an artistic expression of solar activity and humankind's efforts to harness its vast resource of energy. The composition consists of two basic elements: the solar arc and panels.

If a solar panel were to follow the path of the sun from sunrise to sunset, its movement would range from low to high in transverse from east to west. To simulate the sun's energy variation in strength through the course of the day, the solar panel's available area may likewise increase and decrease. Understanding that the sun's altitude varies between summer and winter leads to the idea of alternating the solar panels to reflect these two extremes.

SOLAR ARRAY

SUN WALL COMPETITION

Mission This solar sculpture is intended to make three primary contributions. First, the design seeks to create a major architectural and technology Landmark via implementing design concepts of the solar system. The Landmark status leads to the second contribution of raising public awareness (education) about solar energy as the design is based upon the essential aspects of the solar system. And third, while the sculpture is a fixed element of uniqueness in it's own right, the resulting shadows cast upon the +32,000-sf canvas of concrete will provide an enduring selection of varied compositions. This once bleak wall of sameness will be transformed into a living wall of perpetual change.

Concept The Sun Wall is an artistic expression of nature's solar activity and humankind's technological response to harness its vast resource of energy. The composition consists of two basic elements: the solar arc and panels.

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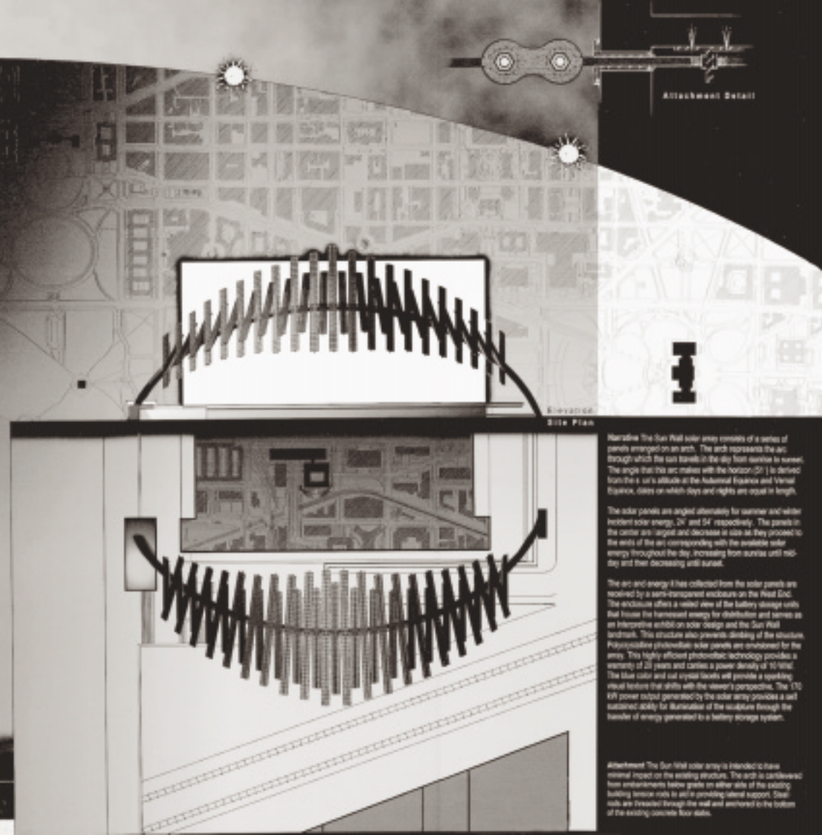
By tilting the panels at an angle equal to the sun's altitude at noon (solar noon) on the dates of the Vernal Equinox and the Autumnal Equinox, the panels will be at their most efficient in order to receive the maximum amount of solar energy.

During the day, as the sun rises, the panels will be at an increasing angle to the horizon to pick up the first rays of the sun's energy.

During the day, the panels will be at an increasing angle to the horizon to pick up more.

During the night, the panels will be at an increasing angle to the horizon to pick up the night.

Solar Tilt Panels



Narrative The Sun Wall solar array consists of a series of panels arranged on an arch. The arch represents the arc through which the sun travels in the sky from sunrise to sunset. The angle that this arc makes with the horizon (31°) is derived from the sun's altitude at the Autumnal Equinox and Vernal Equinox, dates on which days and nights are equal in length.

The solar panels are angled alternately for summer and winter incident solar energy, 24° and 54° respectively. The panels in the center are largest and decrease in size as they proceed to the ends of the arc corresponding with the available solar energy throughout the day, increasing from sunrise until mid-day and then decreasing until sunset.

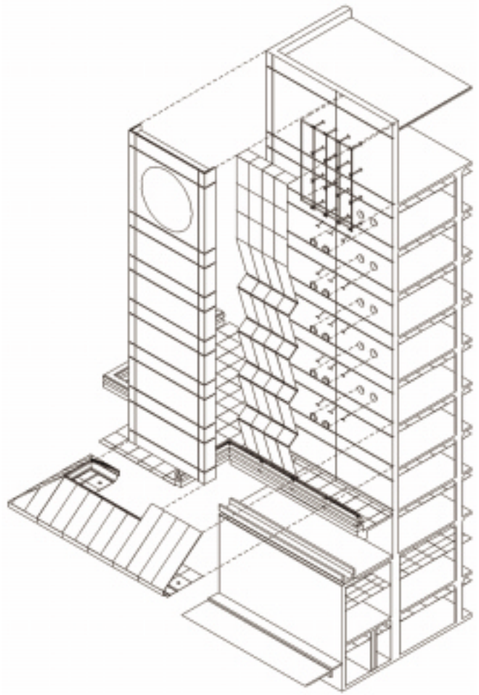
The arc and energy it has collected from the solar panels are received by a semi-transparent enclosure on the West End. The enclosure offers a veiled view of the battery storage units that house the harnessed energy for distribution and serves as an interpretive exhibit on solar design and the Sun Wall landmark. This structure also prevents climbing of the structure. Polycrystalline photovoltaic solar panels are constructed for the array. This highly efficient photovoltaic technology provides a warranty of 20 years and carries a power density of 10 W/sf. The blue color and cut crystal facets will provide a sparkling visual texture that shifts with the viewer's perspective. The 170 kW power output generated by the solar array provides a well sustained ability for illumination of the sculpture through the transfer of energy generated to a battery storage system.

Attachment The Sun Wall solar array is intended to have minimal impact on the existing structure. The arch is cantilevered from embankments below grade on either side of the existing building terrace walls to aid in providing lateral support. Steel rods are threaded through the wall and anchored to the bottom of the existing concrete floor slabs.

SUNWALL • DANIEL MANN JOHNSON & MENDENHALL

TEXAS A&M UNIVERSITY
DR. K. EVERETTE SYLVESTER

PROJECT NUMBER: 191



THE SUN WALL

This Sun Wall design utilizes photovoltaic (PV) technology within a glazed curtain wall to generate an architecture that embodies the individualism of the American public, along with the strength of their collective unity. Allowing optimal electricity production and no shading of the PV elements, the design is a geometrically dependent sawtooth shape supported by structural glazing etched to show the flag of each state. The uppermost facade is suspended structural glazing that collects thermal energy, and the lowermost PV facade protects ground level pedestrians, unifying the vertical elements with the existing structure. Terminating the horizontal thrust of the facade, fortifying vertical pillars echo the architecture of the east and west facades.

Overall, the 95-kW facade generates 156,983 kWh of electricity annually to offset the energy consumption of the building. Reaching temperatures of 187 degrees Fahrenheit, the Sun Wall captures 1,106.36 MBtu/h (324.3 mW) of thermal energy annually to assist the desiccant air-conditioning system during the summer and to preheat the building during the winter. During summer nighttime hours, dehumidification occurs to combat known indoor air-quality problems. When the building cannot benefit from the thermal energy collected, air-handling equipment placed in the vertical pillars ventilates the unwanted heat to maintain production of PV electricity.

THE SUN WALL

Department of Energy Forrestal Headquarters Building

The "Sun Wall" National Solar Design Competition, 2000

The image above shows a view looking eastward beneath the PV Awning.

The Design

The Solar wall is designed to accent the existing architecture by creating vertical pillars that ferrite the building on the south facade. This serves as the rational flow of the PV design by visually integrating the new system. Overall, the facade has four visual components: 1) the existing glass facade, 2) the inside PV section, 3) the lower awning and 4) external quality controls.

Modes of Operation

[illegible]

Electric Energy Production

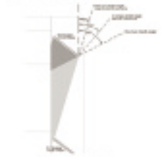
In the designed PV portion of the façade consists of four panels and an awning. The panels are actual 30 degrees from horizontal to face the sun. This maximizes the total light efficiency, grid connection, more crystalline and thin cells (SPR-32, Solar Innovate) manufactured by SP-Systems. The SPR-32, Solar Innovate has the following characteristics and benefits:

- Integrated light collection using a laser grooved textured grid in the cell
- Antireflection coating
- Alternative phosphorus doping of the silicon in the grooves minimizing contamination
- Approx. 17% efficiency
- Operates 100 watt at 0% (Standard Testing Conditions)
- Costs averaging $400.00 ($4.00/watt)
- 10 year product warranty

PV Area Calculation

	Length	Width	Area/unit	# of Units	Total Area
Horizontal Panels	75 cm	100 cm	750 cm²	4	3000 cm²
Angle PV Awning	75 cm	100 cm	750 cm²	4	3000 cm²
Vertical PV Awning	75 cm	100 cm	750 cm²	4	3000 cm²
			Total Area		9000 cm²

*Total area of PV panels is 9 m², which is equal to 1 m² of solar panel. Since 100% energy output (Standard Testing Conditions) is desired, the total area of PV panels is 9 m².

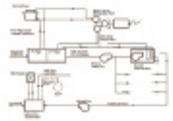


PV Angle Design

The diagram shows the minimum, maximum and average north angles of the sun. In the design, the PV panels tilt up 30 degrees to face more perpendicular to the average north angle (azimuth) of the sun. Using the design data analyzing sun the minimum north angle is used to calculate the south reduction area. As a result, no part of the concrete will receive direct sunlight and the concrete retains glare (PV, white concrete) efficiency (analysis on the solar website [Simulation 2]). As a result, concrete facade panels are reduced during the summer and increased during the winter when it is needed.

Annual Monthly PV Production

The figure shows the monthly PV production of the system. The maximum month production (15,000 kWh) occurs July. The total annual production is 100,000 kWh. To create the data, a simulation of high efficiency (30%) panels (Sunwatts Electric) was performed and the data was conducted using PVF (Visual software [Visual Software, Inc., 1994]).



Operation of a Desiccant Air-Conditioning System

The figure shows a typical desiccant air conditioning system for large office buildings. After removing moisture from the conditioned air and dependent upon the type of desiccant, the desiccant is regenerated using heat, usually from 180 and 300°F, causing the regenerated water from the desiccant to be produced. In the design, the solar wall generates air temperature up to 180 degrees.

Desiccant-Based-Air-Conditioning System

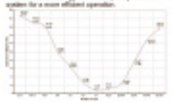
In the design, a desiccant air conditioning system is used to reduce the humidity of the supply air, and subsequently the latent load. The relative humidity of indoor spaces should be maintained at 30% to 60% and the ventilation rates are increased to improve indoor air quality (ASHRAE, 1993). The Sun Wall provides and 20% fresh air of the ahead.

Monthly Space Temperature of Solar Wall

In the figure, the maximum annual temperature in the main space is 90°F and the minimum temperature is 65°F. This data was analyzed using DOE-2 software and required the same space temperature (Simulation [illegible]) as the control (gas heated) gas conversion the total variable (variable cooling).

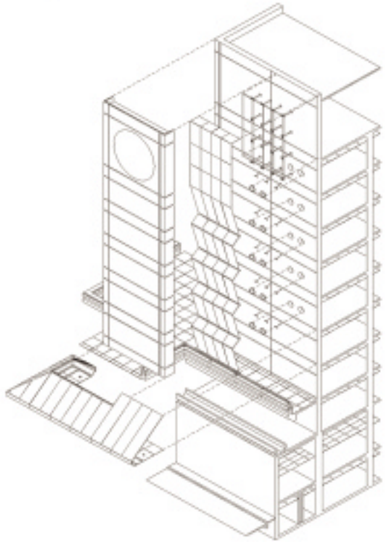
Thermal Energy Production

The design collects thermal energy from the PV façade, the Glass Wall, and the PV Awning. Using air handling units, within the extruded pillars, the air is circulated to recover the heat energy and subsequently and the PV system for a more efficient operation.



Annual Monthly Solar Gain

The figure shows the monthly heat gain (BTU) in the solar wall. The total annual thermal energy is 1,000,000 million (BTU/yr). The data was analyzed using DOE-2 software and required the same space temperature (Simulation [illegible]) as the control (gas heated) gas conversion the total variable (variable cooling).

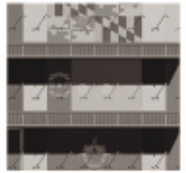


The Glass Facade

Double-layer, the space glass equipment allows the building to breathe naturally. Functionally, the Glass Facade is used as the primary thermal [illegible]

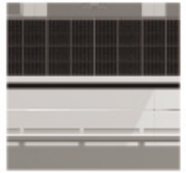
The PV Facade

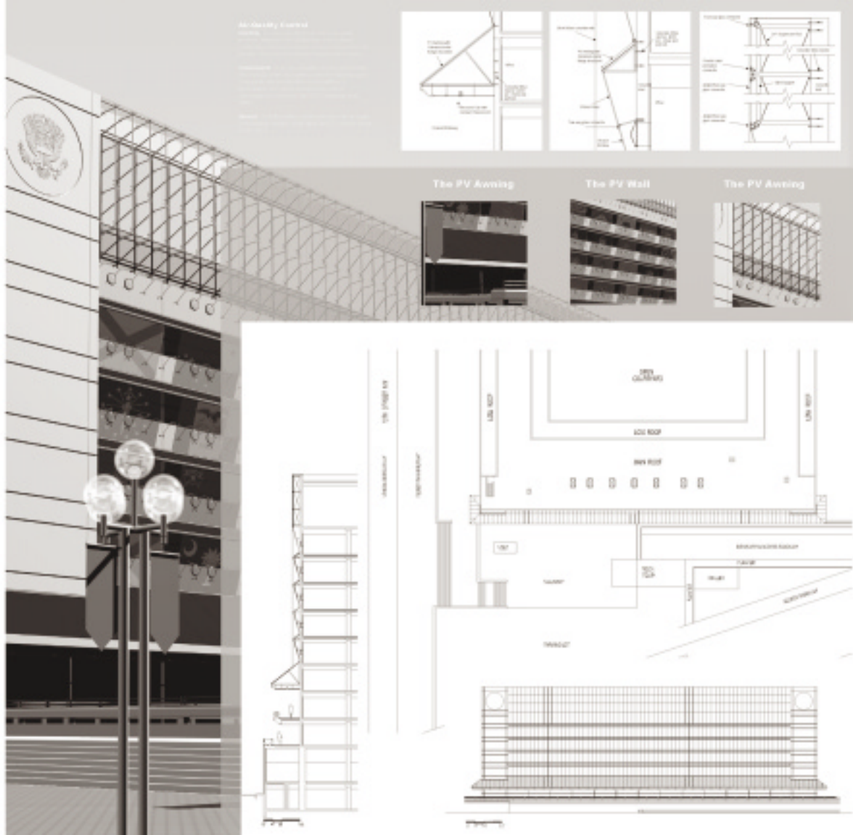
The PV facade uses four rows of PV panels. Opposite of the Awning facility, the PV facade integrates facility of which state in the 100 kWe the glass portion of the facade.



The PV Awning

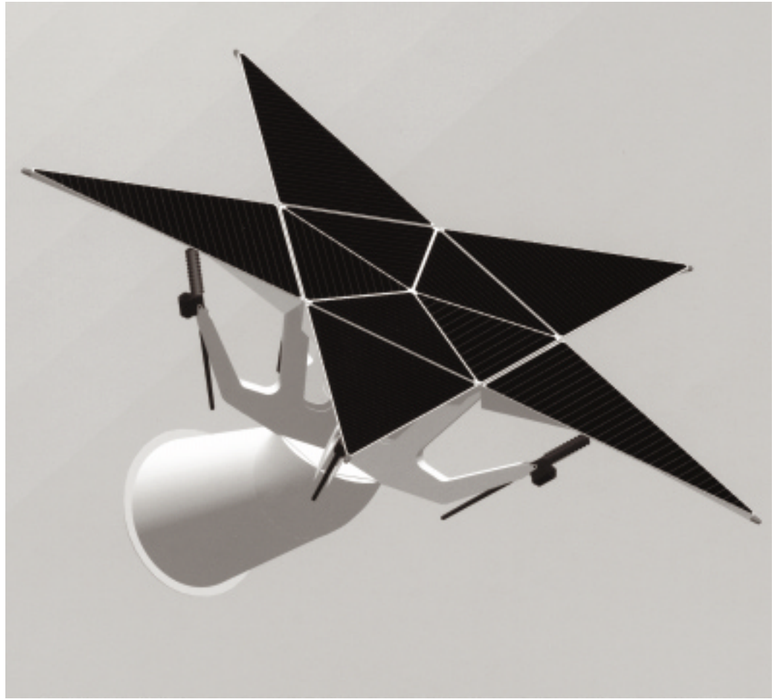
To provide a human scale and protection, a tilted PV awning wraps the base and extensions the extruded pillars. Trains, the sun beneath the awning in the existing outer wall, which the wall shown has been extruded outward.





ALTUS ASSOCIATES
DAVID NIXON
KATHRYN LIM

PROJECT NUMBER: 334



STARWALL

The Starwall design consists of a pattern of 50 photovoltaic stars, one representing each state. The Starwall is intended as a powerful architectural contribution to the Washington, D.C., site where it is located.

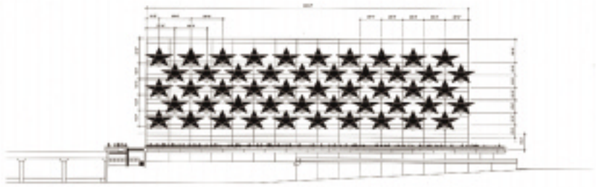
The stars are designed to be lightweight and durable. They are identical and their components can be optimized for multiple production. At each star's core is a skeletal framework attached to the wall by a trunk. The five star points are hinged, with their angles controlled by electric motors and actuator rods. The skeletal frameworks are made of machined and welded aluminum. Face panels are made of honeycomb composite to which photovoltaic sheets are laminated. The trunks and sleeves are made of molded reinforced composite.

Each star can generate two kW of power, making a total of 100 kW for the Starwall. The electric motors and actuator rods are commanded by a computer inside the building. The angles of the star points are continually optimized for solar altitude and azimuth. Adjustments are made every 15 minutes to track the daily sun-path throughout the year for the required latitude. The apexes of the stars are illuminated at night as a visual feature.

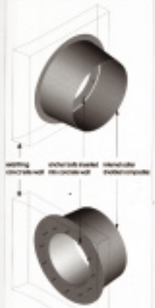
STARWALL • ALTUS ASSOCIATES

STARWALL 1

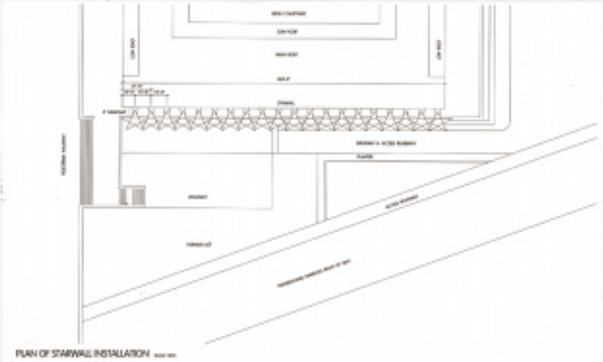
BUILDING SECTION



ELEVATION OF STARWALL INSTALLATION



WALL ATTACHMENT METHOD



PLAN OF STARWALL INSTALLATION

STARWALL 2

CONCEPT

CONFIGURATION

FABRICATION

INSTALLATION

OPERATION

VIEW OF STAR FROM SIDE

VIEW OF STAR FROM FRONT

VIEW OF STAR FROM BENEATH

EXPLODED DIAGRAM OF STAR STRUCTURE

STARWALL 3

CLOSE-UP OF STAR FACE

STAR MOVEMENT: SUMMER SUNPATH

STAR MOVEMENT: WINTER SUNPATH

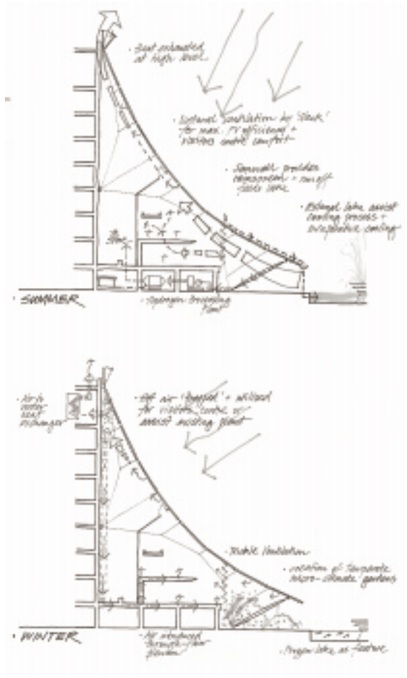
CLOSE-UP OF MOTORS

SIDE ELEVATION OF STAR

MOTION OF STAR POINTS

OVE ARUP & PARTNERS
MAURYA MCCLINTOCK

PROJECT NUMBER: 484



SUNWALL

The Arup team's concept seeks to broaden the message of the total energy role of the sun in the earth's energy cycles: passive, active, converted. It looks beyond the DOE campus to the whole of Washington and beyond in three ways:

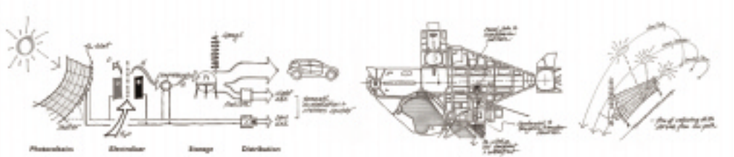
- An architecture derived from the seasonal solar path, with the sun as a valid energy source through the year. A structurally elegant system, this Sunwall provides an overt solar message for commuters on the railway and the people of the city. It also reflects how the Sun drives the Earth's water cycle, which is recycled by the capture of rainfall.

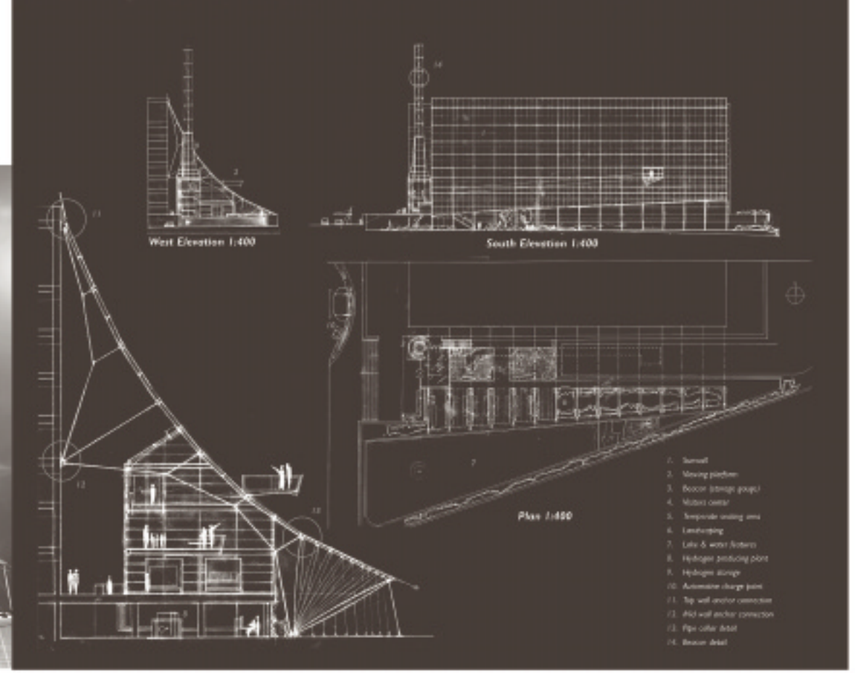
- The creation of a passive microclimate beneath the sweeping solar wall, which serves as a transition space, passively heated by the sun in cool weather and naturally ventilating heat away in hot summer.

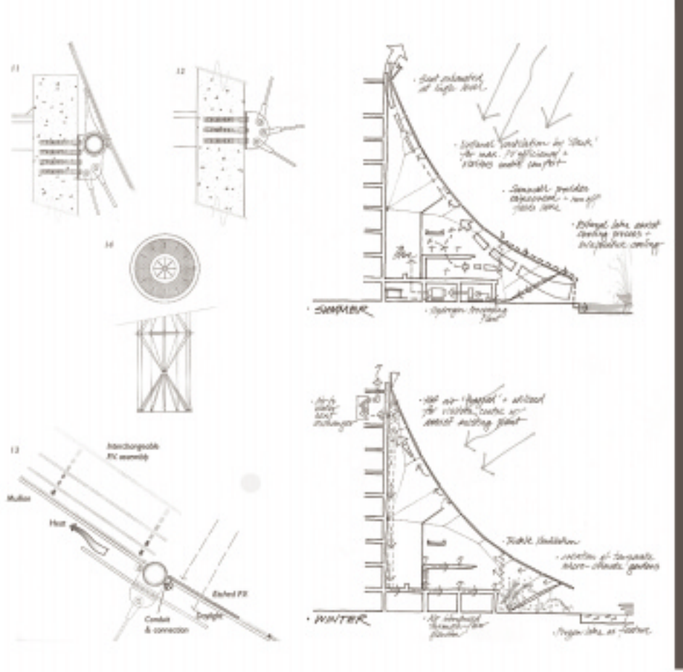
- Plug-and-play technology for the wall's solar arrays, with interchangeable arrays as a proving ground for new technology and new manufacturers, gathering solar energy for by the DOE and visitors' center.

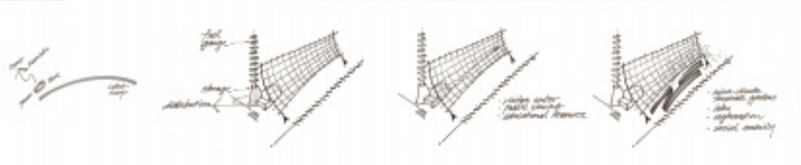
There is a display center allowing the public to experience sustainable energy sources. In addition, a fleet of cars powered by the Sunwall, perhaps by hydrogen fuel cells for DOE staff, could take the clean energy message around Washington. There are spaces for schools and the community, and an inspection platform to experience the vast arrays.

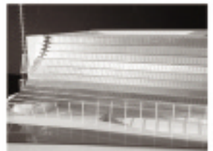
DOE Sunwall - Washington, D.C.

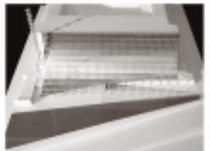


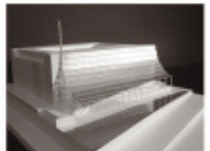


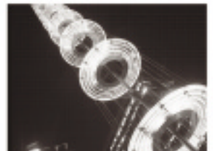


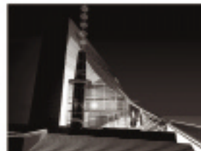






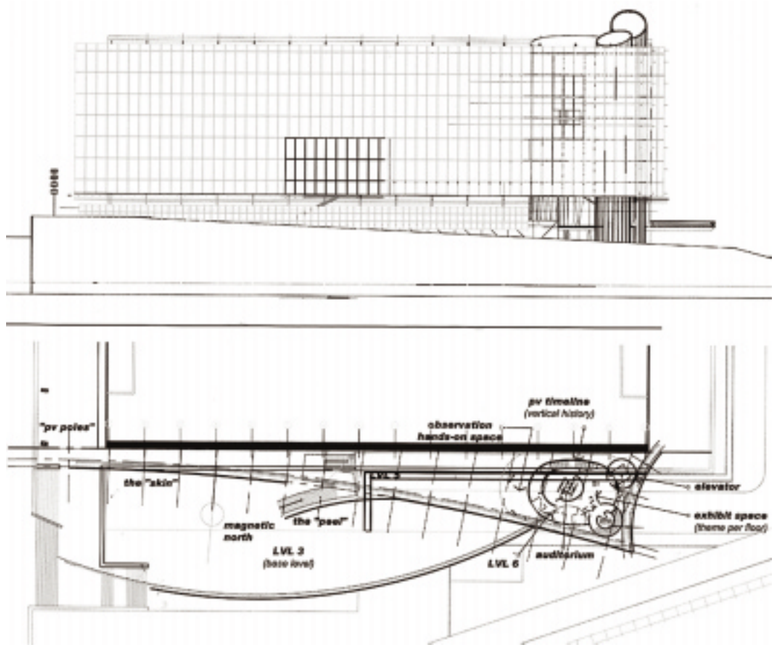






REVIT TECHNOLOGY
KEVIN SETTLEMYRE
KARL DAUBMANN

PROJECT NUMBER: 217



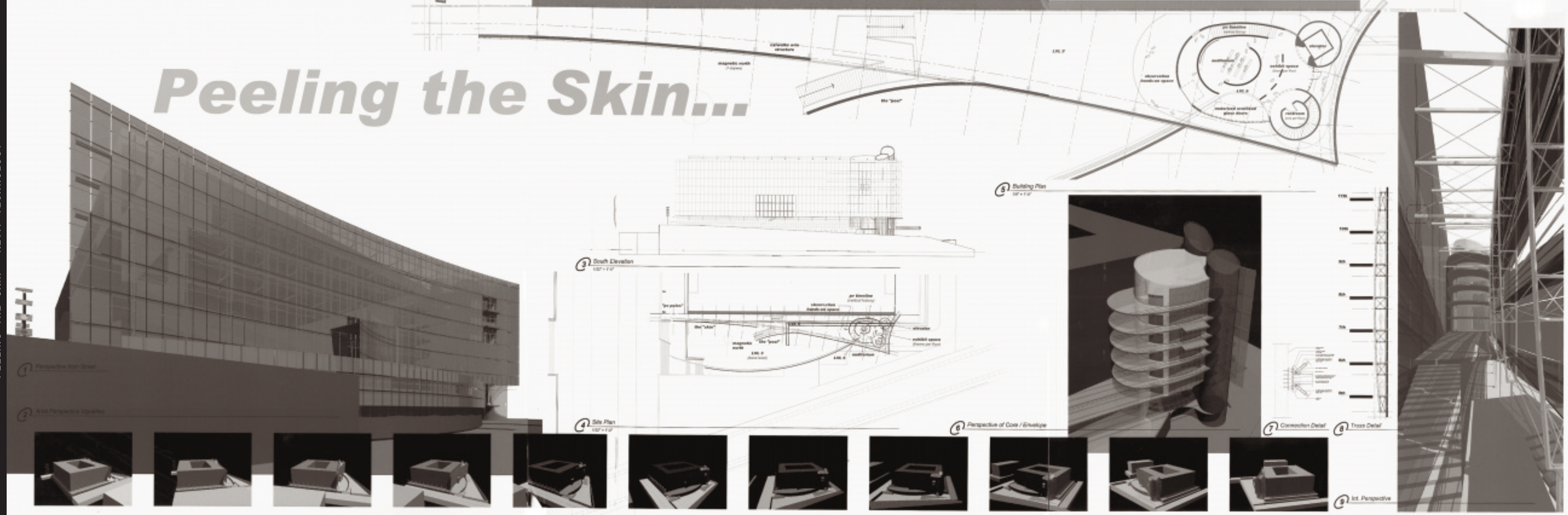
Peeling the skin (layer, filter, peel, energy, skin, light)

The experience…A person walking east of Independence Avenue suddenly catches a glimpse of "blue" to the right. A second glance displays a rhythm of "PV poles" mounted at various angles (24,39,54,90) marching along the Forrestal building. Rounding the corner, the person sees a striking view of the skin as it sweeps into a slight concave shape, peeling away from the building and from itself to form a stair that rises up into the skin. Each step of the ascent unfolds more of a view of the combination of towers, balcony levels, and the catwalks that workers are using to interchange PV panels. Approaching the towers, one can see a series of different battery types behind the glass (providing data on storage, presently and over time) peeling back to a stair rising up to the next level. As one moves vertically, the history of PV technology is told with a theme relating to the past, present, and future at each floor. The top two floors house exhibits on the current state of U.S. companies and how research is shaping the future.

The form is derived from the relationship of the southern exposure to true magnetic north for Washington, D.C. The arc established by this relationship forms a space on the east side of the Forrestal building where a series of forms combine to create an educational tower of the operations of the skin as well as its environment.

Education of the public…occurs by peeling away the layers of complexity behind PV technology to express how the energy is transformed, what it can mean to their everyday lives, the aesthetic qualities of PVs, the size of the industry, what is available on the market, and what is being investigated to shape the innovations of the future.

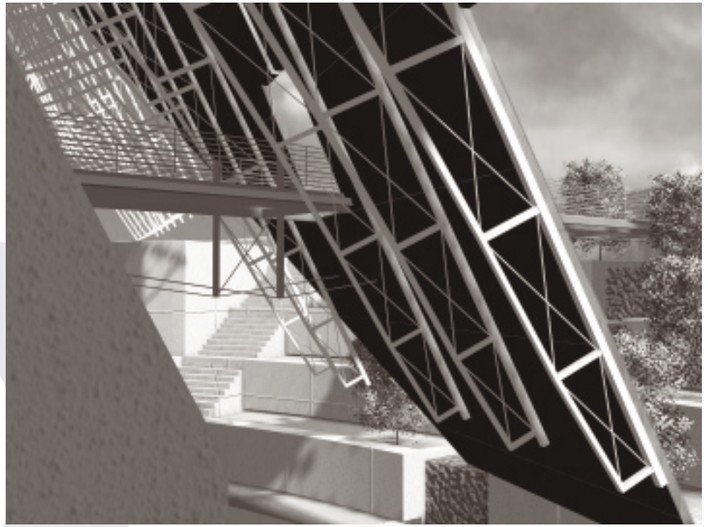
Peeling the Skin...



STEPHAN RICHTER

TEAM MEMBERS
ASHAR NELSON
BEN ALRED

PROJECT NUMBER: 490

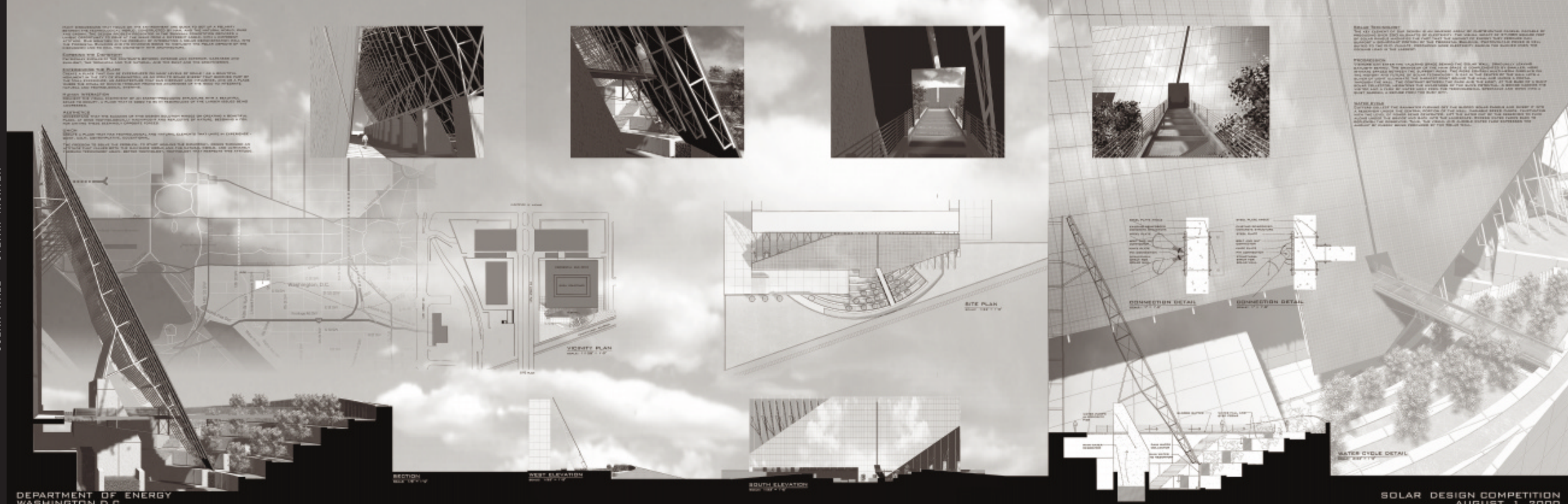


SOLAR WALL

Many environmentally focused discussions are quick to set up a polarity between the technological world and the natural world. We seek to highlight these polar aspects and heal the dichotomy with architecture. This architecture creates a place where technological and natural elements unite experientially, and, in the pilgrimage spirit of Washington, D.C., promotes awareness as a monument to solar energy.

Visitors enter the vaulting space behind the Solar Wall, gradually leaving daylight behind. The grandeur of the main space is complemented by smaller, more intimate spaces between the support piers. The piers contain multimedia displays on the history and future of solar technology. A gap in the center of the wall lets a sliver of light illuminate the darkest point behind the wall and marks a portal through the wall. The contrast between the dark and the light, at the base of a giant solar collector, heightens the awareness of the sun's potential. Variable speed pumps, fluctuating with the level of power being generated, lift water from reservoirs to flow under the bridge and back into the landscape. The flowing water heightens awareness of the sun's working energy through the solar wall—nature working through technology. Finally, the bridge carries the visitor away from the technological spectacle and down into a quiet garden, a refuge from the busy city.

SOLAR WALL • STEFAN RICHTER

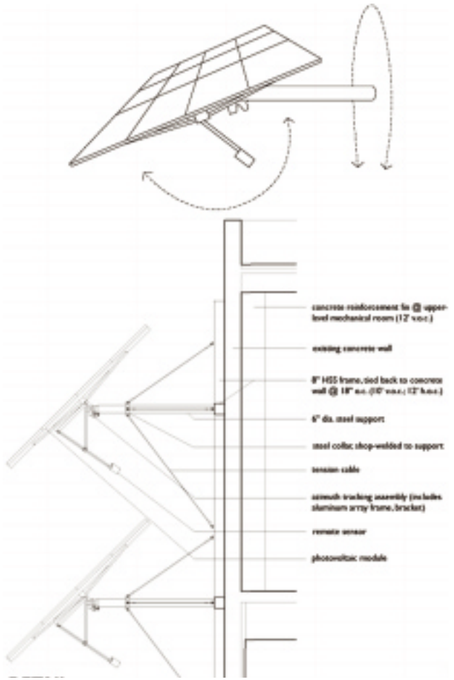


DEPARTMENT OF ENERGY
WASHINGTON D.C.

SOLAR DESIGN COMPETITION
AUGUST 1, 2000

STUDIO FOR ARCHITECTURE
JASON PEARSON

PROJECT NUMBER: 191



AZIMUTH WALLPARK

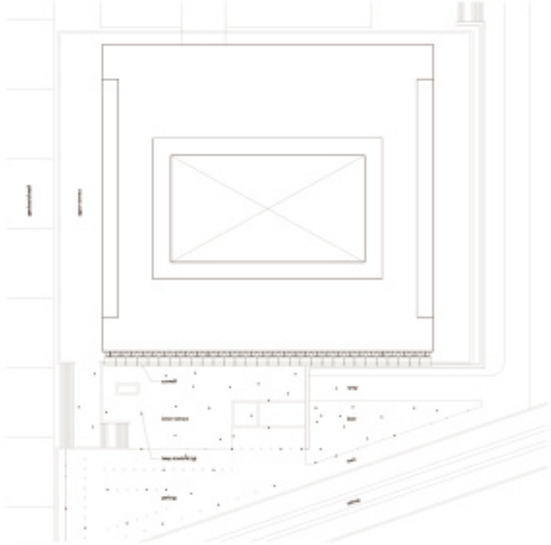
The *Azimuth WallPark* animates the south wall of the Forrestal Building with an array of photovoltaic (PV) panels that continuously track the sun, creating a constantly changing performance across the face of the building with a vertical field of reflections.

During daylight hours, the panels maximize their solar exposure by tracking the path of the sun across the sky. Simultaneously, reflections in their glass surfaces create a tessellated *Wall of Sky* that shifts and changes with the passing of the day and the motion of the panels. The panels' motion is both a public representation of the sun's energy and a visual transformation of the wall.

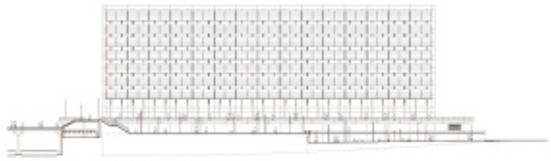
As the sun passes below the horizon, the panels continue to track its path, completing a full 360-degree revolution each day. Overnight, the gradually increasing downward orientation of the panels offers shifting reflections of a new public space south of the building, illuminated by a forest of light standards powered with a portion of the excess energy generated by the system. The lights of passing trains and traffic join these reflections on the facade to create a *Park of Light*.

WALL OF SKY

During daylight hours, the photovoltaic panels maximize their exposure by tracking the path of the sun across the sky. Simultaneously, their glass surfaces, presenting a more oblique angle of incidence to ground level viewers, create a reflected wall of sky that shifts and changes with the passing of the day and the motion of the panels. The motion of the panels becomes both a public representation of the movement and energy of the sun and an aesthetic transformation of the south wall of the Forrestal Building.



PLAN 1:400



ELEVATION 1:400

AZIMUTH WALLPARK

Approach

The Azimuth WallPark creates a new kind of performative urban experience by translating a typically horizontal energy system – the photovoltaic array – onto a vertical urban surface. The design thus:

- creates a highly visible public demonstration of building-integrated solar technology
- enhances the esthetic character of the Forrestal Building, and
- enhances the urban quality of the surrounding area

The Azimuth WallPark provides a new source of electrical energy for the building and its systems AND a new source of urban energy for the surrounding area.

Azimuth Tracking

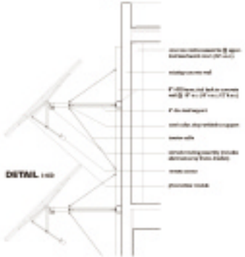
Computerized azimuth tracking systems are widely used in PV arrays around the world, and they are specifically appropriate to this location. From a functional standpoint, field testing in nearby Baltimore has demonstrated that dual-axis azimuth tracking enhances the energy capacity of PV modules by an average of 30% on an annual basis. But perhaps the most unique and important benefits of azimuth tracking systems are aesthetic. Because the PV panels always face the sun, any reflected solar radiation is directed back along the same axis, meaning that the panels will generate NO SOLAR GLARE. The reprad reflections visible in the polished glass of the PV modules will always be sky, building, or ground, but never the sun itself. From a technical standpoint, the rotation of the array onto a vertical surface is possible because the PV racks in an azimuth array are each hinged at their precise center of gravity, meaning that rotation about this point requires minimal outlay of energy.

Energy output

The total energy capacity of the array is 34.66kW, based on typical output estimates for the specified AstroPower modules. Again using Baltimore data for dual-axis tracking systems, average solar radiation striking the array will be 15,000kWh/day. Energy will be used to:

- provide energy to the Complex and its systems
- sell energy back to the utility through grid connection
- provide energy for the proposed nighttime illumination

The installation will use AstroPower APG PV modules mounted in Watson APMS-18 (AZ-200) Gear Drive Trackers.



DETAIL 1:100

PARK OF LIGHT WALL OF LIGHT

In contrast to typical azimuth tracking systems, which reverse their motion overnight to return to an eastern orientation, the Sunwall panels continue to track the sun, even after it has passed beyond the horizon, completing a full 360 degree revolution each day. Overnight, the gradually increasing downward orientation of the panels offers changing reflections of the new public space – a park of light – created with a portion of the excess energy generated by the system. The lights of passing cars and traffic provide further visual animation of the facade.

DESIGN PROGRAM

Introduction:

The United States Department of Energy's (DOE) Sunwall National Solar Design Competition challenged entrants to create a solar system that is both technologically advanced and visually exciting for the south-facing wall of DOE's Forrestal headquarters building in Washington, D.C. Sunwall is intended to be a major architectural and technological landmark that will demonstrate the department's commitment to developing clean energy technologies to power the 21st century. The winning design is being considered for future installation on the Forrestal Building.

The Challenge:

The Sunwall Design Competition invited architects, building design professionals, engineers, and energy technology companies to demonstrate how the beauty and grandeur of public buildings in Washington can go hand-in-hand with environmental sensitivity. The 32,000-square-foot blank concrete wall is within view of the U.S. Capitol and the Washington Monument, and is around the corner from the famous Smithsonian Institution "castle" on the National Mall.

The underlying objectives of the design competition were to apply the creative and innovative forces of architectural design to advance solar energy use in buildings. A jury of noted professionals in solar architecture and public building design, among other fields, was convened to evaluate each entry on its individualistic and artistic expression. The winning design will be showcased at such prominent locations as the DOE lobby, the National Renewable Energy Laboratory (NREL) Visitor Center in Golden, Colo., and The American Institute of Architects (AIA) annual convention. It will also be placed on the Web site for reference.

Goals and Objectives of the Sunwall Design Competition:

Improve the aesthetics of the Forrestal Building - Architecturally, the building typifies the formal, Federal office building architectural style predominant in the Southwest quadrant of Washington. The Forrestal Building's repeating window/cell pattern is absent from the south wall, which is composed instead of 18-inch thick, poured-in-place concrete. Cut into the entire exterior surface is a broad grid pattern that mirrors the floor lines and window pattern from the rest of the building. The southern orientation and considerable set-back from neighboring buildings (of a few hundred feet) make it an ideal site for solar exposure. At the base of the wall is an eight-foot-wide walkway along its entire length. On the outside edge of the walkway is a concrete knee wall with a tubular railing on top. As constructed, the south wall should be able to support the weight of solar energy devices anchored to it.

Demonstrate and promote solar technology - Solar energy devices convert sunlight either directly into electricity with photovoltaic (PV) technology, or into thermal energy using either air or a liquid as a collection and transfer medium. Several solar technologies have experienced increased usage and tremendous industrial growth in recent years, mostly driven by their attributes of being non-polluting, modular in size and operation, and suited for remote siting. However, the existing installed capacity and current usage of all kinds of solar technologies is dwarfed by the potential future contribution that these technologies could make toward satisfying the world's electricity and thermal energy needs. One of the ways that solar energy usage is expected to grow most rapidly in the near future is through building-integrated photovoltaics (BIPV), where the solar devices are incorporated into the building's exterior. In essence, this design competition is meant to show the possibilities of solar technologies, of building design and energy usage, and how a solar-based, 21st-century Washington, D.C., and America might look. For additional information on solar energy technologies, please consult www.eren.doe.gov.

Facilitate successful approval of the installation - DOE plans to build the winning design. The relative importance of the three evaluation criteria (below) show that DOE is most interested in an aesthetically pleasing design that will help garner ultimate support.

Bring utility and value to otherwise unproductive wall space - For any building in the Northern Hemisphere, a south-facing wall or roof is the ideal orientation for solar energy collection. Since the Forrestal's south wall is blank concrete, it can easily be translated into an ideal canvas for aesthetic and environmental expression. In addition to the 32,100 square feet of wall surface, the proposed design can come out from the exterior surface of the wall to the far end of the Forrestal Building property (along the railroad tracks) and must stay at least 15 feet above any walkway. The solar design cannot impede, in any way, the cooling and other mechanical equipment located behind the Forrestal building and it cannot be climbable.

Stimulate solar design practices within the architectural and building professions - Commercial and institutional buildings are major electricity consumers and many of them have large southern wall and roof areas. By stimulating architects and building designers to use solar design practices in their commercial buildings, DOE hopes to create a new expansion and expression of solar energy usage.

Rules:

The solar energy system designed (photovoltaic and solar thermal) can use the entire wall area of 32,100 square feet (107 feet high by 300 feet long).

The solar products designed in the solar system must be manufactured and produced in the United States or its territories.

The integrity of the existing wall must not be compromised in any way. This does not preclude anchoring to the poured-in-place concrete wall, and entrants are required to include attachment details.

The solar system must generate a minimum of 100 kW (or the equivalent thermal energy).

Continued

Due to the nature of this project, two governing bodies—The National Capital Planning Commission (NCPC) and The Commission of Fine Arts (CFA)—will have to review and approve any design that would be built on the Forrestal Building. Accordingly, part of the challenge of this competition was to create an ultimately approvable design for the DOE Sunwall.

The U.S. General Services Administration will also have to review and approve any design built on the Forrestal Building.

Sponsors:

The Sun Wall Design Competition is sponsored by U.S. Department of Energy, The American Institute of Architects, the National Renewable Energy Laboratory, and the Architectural Engineering Institute.

Evaluation Criteria:

Aesthetics: Aesthetics were the most important consideration. To receive NCPC and CFA approval and ultimately be built, the design had to be attractive and in harmony with the architecture of the Forrestal Building and its environs. Pierre L'Enfant's design for the new capital emphasized architectural and aesthetic quality, and this remains a priority. His design, through its stateliness and grandeur, showcases Washington, D.C., as a world capital.

While many aesthetic considerations may involve individual interpretations, some fundamental aspects are the balance and proportions of any addition to a building. Also, a building addition should appear to be fully integrated into the design of the original building and avoid the appearance of being put on afterward or as an afterthough.

Energy Production: While the primary objective of the Sunwall Design Competition is to maximize aesthetic and artistic expression, a reasonable amount of energy must be generated to justify the investment. Accordingly, energy production was also an important basis upon which competition entrants were judged. The Competition's evaluation criteria allowed for a reasonable tradeoff in energy production for aesthetic or creative functions. Entrants had to explain how the energy production calculations were derived.

Cost Effectiveness: Any federal investment in a building energy system needs to be cost effective to justify the public expenditure. The directives under the Federal Energy Management Program (FEMP) are to "identify and procure the best, most cost-effective energy saving projects." Although this project is far from the usual federal retrofit, it still had to demonstrate a certain measure of cost-effectiveness. While third in importance in this competition, it remained a strong consideration because of its importance overall in building projects.

Awards:

A cash prize of $20,000 was awarded to the winning design. Second and third place awards, as well as honorable mentions for professional and student categories, were also given.

Significance to DOE:

When installed on the Forrestal south wall, the Sunwall will be the largest such solar energy system on any federal building in the United States, and one of the largest on any building in the nation. The largest federal installation is at the Yuma Army Proving Grounds in Arizona, which has a 450-kW PV system controlling all its water, including back-up pumping. However, the system is located next to, and is not integrated into, the building. The largest building-integrated solar system is the Western Area Power Administration's Elverta system, which is less than 100 kW counting all subsystems. Because residential and commercial buildings account for more than one-third of primary energy demand and two-thirds of electricity demand, this project will show that clean energy technologies can offset building energy usage while being visually pleasing and respectful of the environment.

History and Background of the Forrestal Building:

The James Forrestal Building, named for the first Secretary of Defense, was the first building to be designed and constructed specifically for the Department of Defense (DOD) rather than a particular military service. Congress authorized the construction of the building in 1961, and it was intended as a manifestation of President John F. Kennedy's effort to improve the quality of federal government architecture. Originally designated Federal Office Building #5, the building was renamed by President Lyndon B. Johnson in 1965, and DOD staff moved into the building in April 1969. On August 3, 1977, the James Forrestal Building was selected to be the headquarters for the newly established Department of Energy. James R. Schlesinger, the first Secretary of Energy, with his immediate staff and other DOE employees, began working at the Forrestal Building on May 1, 1978.

The Forrestal Building is actually a complex of three interconnected buildings, including a cafeteria and child development center. The major section, a long narrow structure running parallel to Independence Avenue between 9th and 11th streets S.W., is raised on 36-foot pilotis (or piers) bridging the 10th Street Mall (also known as L'Enfant Promenade) at its northern entrance. The unusual configuration resulted from the need to improve building access for DOD. At street level, the vista from the rear of the Smithsonian Castle, south along L'Enfant Promenade, is nearly unbroken. Pedestrian and automobile traffic passes below the building.

L'ENFANT PROMENADE • FORRESTAL BUILDING • FORRESTAL BUILDING DETAIL

SUNWALL DESIGN COMPETITION JURY
RICK HENDRICKS
RALPH JOHNSON
SANDRA MENDLER
BART PRINCE
STEPHEN J. STRONG

JURY MEMBERS (left to right); Bart Prince, Rick Hendricks, Sandra Mendler, Ralph Johnson, and Steven J. Strong

A jury composed of noted professionals in architecture, solar engineering and design, and public building design met in late-August 2000 in Washington, D.C., to judge the entries.

Mr. Rick Hendricks a professional engineer with the U.S. General Services Administration, Washington, D.C., studied mechanical engineering at the University of Illinois and has over 30 years of experience in construction and facility management, including 20 with the federal government.

Mr. Ralph Johnson of Perkins and Will, Chicago, is an internationally known architect who has received over 30 design awards in the past eight years. His architecture degrees are from the University of Illinois and Harvard University.

Ms. Sandra Mendler is an architect and design principal with CUH2A, Inc.,Washington, D.C. She has architecture degrees from Washington University and Pratt Institute. She is a leader in "green" architecture and recently won the Environmental Sensitivity Award from the Construction Specifications Institute.

Mr. Bart Prince of Albuquerque is an architect best known for his unusual and creative use of design and materials. His architecture degree is from Arizona State University and he has received numerous architectural design awards.

Mr. Steven J. Strong, is president of Solar Design Associates, Harvard, Massachusetts. He studied architecture at Northeastern University. He is the U.S. representative to the International Energy Agency's working group on PV in Buildings and is the author of "The Solar Electric House."

JURY COMMENTS

RH: Really, this was a pretty straightforward kind of a challenge, and out of 145 entries we had only several themes… the only radically changed one is this one (Solar Sails #267). The technology's not radical, but the idea of making it an art statement is. Sort of a whimsical thing instead of a pure tech solution. There were many with flags… we felt that whatever picture, whatever billboard effect you get is really inappropriate for that particular site. There's no possible way you can even see it so you don't get a long panorama or you don't get to see it from miles away.

SM: We all thought, who would ever see this billboard? Because, what we're searching for is building integration. Here in particular there wasn't even an audience to see that billboard.

RJ: If you had a wonderful public space in front of this wall, then a billboard might make sense. What we wanted to do with this project is actually make a space. I think that's something we talked about before we started reviewing this. It should be expressive of solar technology but should also make a public place. You can't do that with a billboard.

SM: You should draw people to it so you can engage them and get them looking at it more closely rather than just creating an image.

RH: And I think all three of them do that. The top three actually create a sliver of space behind it; it encourages you to go in there. And that space exists right now, the walkway exists.

RJ: We wrestled with that question from the start, how far to come out, but I think we have to agree that the conclusion is if it is at all possible, it should extend out into the site. Any of these three all have implications all the way out to the rim . We strongly suggest that this project go out as far as it can. In fact, the winning scheme has this pond of water. Not only is it interesting visually, it's part of the energy solution.

SM: It solves the problem of masking over all the jumble of things you have below, which is really problematic.

RJ: Wind would blow over the water and cool the air around the space.

SS: I think it's fair to say that every scheme, or proposal, was strengthened by addressing the entire site, either landscaping, park development…

BP: Rather than just a two-dimensional wall. It seems like they all saw the need to bring people to it. Well, actually, what I think they saw was that people are going to come to it when they see it, and there better be something when they get there.

SM: The schemes that were selected for 1st, 2nd, and 3rd all play with light in an interesting way. And we thought there's something about the way photovoltaics are evolving that is a way of dealing with light and shadow and creating a light-filtering effect that can make these spaces a lot nicer to be in.

RH: The application on the buildings is maybe not so much curtain walls but maybe layered buildings. Maybe not on all four sides because you'd want to respond to the different configurations, but this could be a prototype of a kind of layered look, of creating a kind of secondary environmental layer. Between the outside and the inside.

SM: There were some themes very similar to this that actually created area underneath the wall, and these each create a transitional space itself, really building a building. It was a bit much to actually create a whole program and create a whole building when they hadn't been asked to create that kind of transitional space. Like an outside arcade that encourages people to congregate.

RH: This one here (Sunwall #327), the panel that's sort of slipped off the wall, it's sort of interesting because of that; and it's got this combination of being extremely factory made and standard, but it has this life cycle where it slipped off the wall and in the process it optimized its configuration for collecting solar energy.

SM: We talked about that one (Sunwall #327) quite a lot. Even though it's not technically a wall anymore, in transforming it into a roof, it collects more solar energy in that orientation.

RH: We also thought of it in terms that this will probably emerge as a pretty dominant symbol of the Department of Energy. There will be a lot of news teams and they'll no longer want to stand in front of the building with the sign that says DOE, they'll stand up here and shoot in front of the solar wall, and you would probably want that. So when you look at this, it has a flatter aspect to it…we thought that the winner definitely reads solar energy. It's very strong, even though it's more of an expected result. Pretty much everyone could relate to it. People who aren't experienced with this nice space are still looking at this on the 6 o'clock news and thinking, oh, this is the DOE. It's identifiable as a solar device.

SM: The winner's also very rich in that in addition to the solar electric, PV cells, there's solar thermal, where water is heated in a solar thermal array, which is very efficient; there's also a cavity, an airspace between the layers of glass that heat air during the winter months; and there's the passive cooling of the water pond as well. There are a whole bunch of things: behind that wall are stacks that create ventilation behind the space. So there were multiple issues that were being addressed in a very integrated, kind of sophisticated way, which was a big part of why we chose this one...

BP: Well, they're providing shade in the summer, with the solid photovoltaic part, then they've got the glass part, which allows sun through in the winter time, so you don't have the cold air behind it.

RH: The one here (Suncurtain/Sunhall #285), which is really a hanging curtain, is extremely practical. This one, you could probably actually build based on the schematic available right now. Depending on how you anchor it down, it could be either more or less flexible; it could be really interesting. Maybe it could move a little bit in the wind, and it doesn't have a lot of moving parts, even though it looks like it has lots of stuff happening. This one down here (Solar Sails #267) has a lot of moving parts but it is extremely interesting. You know, we're trying to figure it out. It's got some really nice elements: they have wedge-spaced shape against the wall, they have this tower that is supposed to give you an analog representation of what's going on even though it shadows some of the collectors. It's got a lot of things happening. It couldn't win, but it's got lots of things happening, lots of creativity.

SM: The other 2nd place scheme, the real whimsical one (Solar Sails #267), we talked about quite a lot. On the one hand it says solar could be anything. It's almost the exact opposite of the wall that says solar. This could have been absolutely anything: metal mesh, or anything. That made an interesting statement, that solar doesn't have to be solar, it could be a very playful, imaginative, fun function on the plaza that generates electricity as well. So it's kind of neat, almost the polar opposite of the first one that was chosen. The message isn't clear or overt. Just very playful, because it's got the plants growing through the trellis, it's sort of making a play off the trellis, the vines that grow on the trellis, which is also solar, so it's very playful and poetic that way.

SS: The 1st place award presents a refined concept that can be applied to virtually any vertical wall as a retrofit. And therefore it is replicable, which is desirable. It fits this particular site requirement, but it could also be scaled to fit many others.

SM: Same with the other 2nd place winner.

RH: But it's slightly better because you've got the see-through glass.

SS: Yes, I agree.

RH: There's something about the vertical, articulated line (Sunwall #56). It really is a minimalist sculpture, actually. Pretty direct expression—the solar vertical panels picked up on the expression of classical proportions in a very abstract way of the government buildings in Washington.

RJ: Solar columns.

RH: Yeah it's the one that has the most pronounced overlap, or it extends beyond the building, which would tend to draw you up the L'Enfant Promenade because you would see at least the last two or three of those fins from down Independence Ave. And it also extends over the top of the building; I don't know if you would—I mean, you wouldn't be able to see that, but instead of being applied to the building, the building would become smaller.

SM: We do have to mention this one (Solar Grass Field #280). We haven't mentioned anything so obvious. We felt it was not practical, but just intriguing and really creative and one of these far-out ideas that one day people will figure out what to do with this kind of interesting image in the future. But we just felt it was so engaging as an image that it deserved recognition.

SM: We talked about, before we got started, what we thought as we went through the teams, what we were looking for and what we were recognizing. And I think some of these kind of give an important context for what we were doing here.

1) An idea clearly expressed, that is compelling, engaging
2) An idea that will inspire the design community—the design community in essence is the gatekeeper of the technology, and we wanted something that would inspire them to work further with solar technology
3) As taxpayers, is this a good investment? We struggled with this quite a bit, trying to balance cost and benefit
4) Are these good models for future endeavors?
5) Will people experience this? Will it just be a fleeting moment as they drive by, or will they come up and occupy this space and really experience the solar wall?
6) Will the design help people understand what the issues are related to photovoltaics?
7) Do they provide multiple benefits? Are they integrated solutions that accomplish multiple things?
8) Is it appropriate to the site and context?
9) And, what are the aesthetics?

This is what we were thinking about as we culled through all of these schemes.

What about your winning student design?

BP: It was very similar to the winner. We didn't know it was a student design at first.

RH: The student one, which we didn't know was a student one, was competing in the great draped solution, cable-formed approach. It was very strong—the collector panels were clearly floating. They don't suggest a solid sheet, but are actually individual tiles floating in a grid of wires. That we thought of as a positive, it would make it much easier to get the clearances to build it. It also would move more. It didn't have as many energy strategies on the board as the winner did, but it clearly was extremely creative.

BP: It's so interesting that the student scheme was right up there at the top with the rest of them.

SM: It was slightly more roof than wall in that it angled out more and captures more space, more plaza space. The reason why it didn't make the final cut was just because the other scheme that we chose as the first scheme had more design synergy and more energy strategies integrated into it.

Are any of the things you see in these competition entries ideas that you would like to see taken out into other venues? Are these viable options?

BP: Conceptually, what I would like to see, we talked about the replicability and I'm actually against that for the most part. I'd actually like to see an idea or concept replicated in another form, but not so much the idea that we would see a design on every straight wall across the country. We were looking for concepts that would let people see how they could take something they were trying to do and apply the idea in their own form.

SM: Currently, most of the applications of solar panels are done as an add-on attachment to an existing structure. And we thought that these designs were presenting some exciting ways to think about solar panels in a different way, to think about them as a skin, a light-permeable skin, or to think about them as a horizontal Venetian blind that was more of an awning structure. And so yeah, there's more richness in the way the panels were used to create space and really a lot of interesting ways of filtering light and creating a microclimate outside the building. This kind of unique problem led to solutions that are unique to here, because there's no building that's being created. But it was interesting that some of them stretch beyond the surface of the building. Many attempted to do something beyond just treat this as the surface of a building.

RH: A couple of things that could go out to the world…we think that this one (Solar Sails #267) could go out to the rest of the world—it just needs a spot, needs to be built someplace. It probably couldn't be built in the bureaucracy that exists, but it would be nice to see it. Only once!

BP: As a concept, it shows a way to treat the solar so it is not just an appliqué stuck on the building. There are lots of ways to treat it, and this is more sculptural, playful, not just a big wall of glass. Hopefully people will realize that they too can do something to bring this into their building, and do it in their own way.

RJ: It's a sculpture first and solar second, which might work on another building, but at the DOE solar was first.

SM: That was important too, that it doesn't have to be used only in cases where you're being self-conscious about materials and making a statement about solar, but it could be used in other ways.

How do you think the Commission of Fine Arts and the National Capital Planning Commission will view these?

RH: I think they might…we thought actually that they might probably prefer the vertical line one because of the architectural symbolism of Washington. But I would think that the winning one is actually doable because it's in such an obscure location that I think they would be a little more open to it.

SS: I don't think we could do it on the side of the Smithsonian.

RH: We didn't consider these as finished designs, they just suggest things, although maybe more or less strongly. But there are definitely some challenges left besides just engineering them out and building them. It's probably the responsibility of the DOE to get it to be used. They have to either hold activities there themselves, or things have to go on to make the space livable and to encourage people to get under it. Some of them—not the winners—had a lot of indicators under them, analog or digital things, saying what's happening: this is how much energy is being created, this is how much storage we have, this is how much is left. I think this one (Sunwall #280) is pretty blank in that area, so there's a need to animate it more, to engage people more, make it more of a hands-on thing. You will want to make it so people want to go under that canopy, and when they get there it shouldn't just be all cables.

SM: We thought you very much could create a space under it, a pavilion space or restaurants and cafés during lunch hour to make it a place that would draw people. One of the concerns, even with the one with the vertical blinds, was that it grab you as a space that you would respond to positively. It's also because it's a very cold and in some ways uninviting place now. I guess …we were looking for an imagery that was more inviting and would help improve and draw people to that space and encourage that space to be more used.

BP: From the walkway out on the end you can see the Capitol building and the Jefferson Memorial. I mean, it brings you out to that corner and high enough that you can see this corridor. But it looks to me like they've gotten you out enough and high enough that you could really experience the rest of the grid that's out there, which is hard to see right now.

SS: One theme is clear—almost every entry with any depth went beyond the parameters of a solar wall.

RH: There's a hodgepodge of mechanical equipment there, and the winning one hides that with a pond—it's like a bread pan above that level. I think that was one of the challenges of the site. In the whimsical one, you sort of use that to your advantage. Part of the strategy may be to offer double-level parking in that area below, and put a very shallow pond above, which offers the evaporative cooling.

SM: We feel the scheme would work without the pond, because the space behind the wall is the most valuable. But a green space, wildflowers, would be nice.

Did it raise your excitement level and awareness of PVs to be involved in this project?

RJ: I was very excited, the whole idea of solar panels being transparent, not opaque. After talking to Steve we all wanted to go back and create our own wall! I think what Steve was talking about earlier, which was not manifested, was the change in transparency you can achieve by sort of carving back, etching out the glass. I think that's a strategy that could have a lot of areas of deployment.

RH: I mean, we were talking about using solar panels as glazing panels, not as appliqué, capturing some costs you have already in structure, fenestration, hardware, labor, and having them as collector panels instead of fretted glass. This one, for example, has different densities of collectors on it (Sunwall #280).

SM: Yeah, well, need the lead filtering on that side because it gets so bright and hot, and the different densities provide shade and collect solar energy.

SS: The opaque cells are spaced to let light get through. Right now the ability of the industry to provide large panels with laser etching in a large format like that just isn't here yet. However, if you're using discrete opening crystalline cells, your ability to build large format is really just shooting for the right technology.

SM: What would be interesting is if that design was refined to actually introduce both technologies.

SS: Some entries did go deliberately out of their way to offer two or three or even four manufacturers, sort of a mix-and-match routine, thinking perhaps that the politics of the process might actually drive equal opportunity. But unfortunately—and I was actually looking for some way to bring those further forward in the process—there wasn't enough there otherwise to merit them. In fact, if this is brought further forward, you could have different solar cells, different manufacturers, bidding for color cells, possibly thin film, and laser etched bands in there somewhere. So there's lots of variations on the theme.

SUNWALL DESIGN COMPETITION JURY

CREDITS

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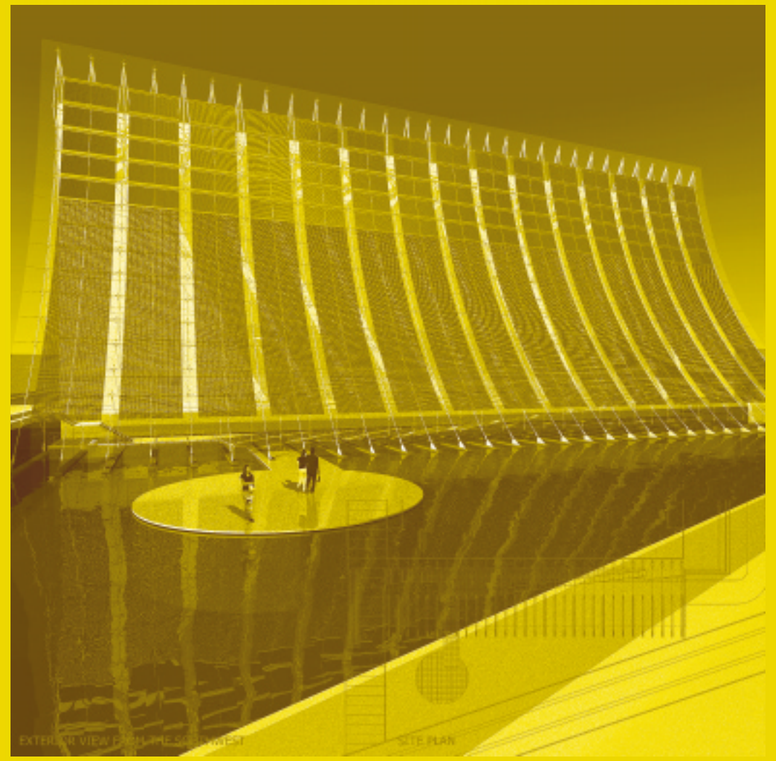

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